INVENTORY OF SELECTED WATER, LAND AND RELATED RESOURCES DATA

ISLAND OF HAWAII
TYPE IV RIVER BASIN SURVEY

June 1975

COVER PHOTO BY HOWARD PIERCE

INVENTORY OF SELECTED WATER, LAND AND RELATED RESOURCES DATA FOR THE ISLAND OF HAWAII, HAWAII

A TYPE IV USDA RIVER BASIN SURVEY

June 1975

PREPARED BY:

UNITED STATES DEPARTMENT OF AGRICULTURE
Economic Research Service/Forest Service/Soil Conservation Service

In cooperation with:

STATE OF HAWAII
Department of Land and Natural Resources

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SUMMARY

This reports presents information on the agricultural, rural, and upstream aspects of the island of Hawaii. This cooperative Type 4 river basin study was made under the authority of Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 83-566, as amended). The state of Hawaii requested the study and participated through the Department of Land and Natural Resources and its various divisions.

Objectives and Scope of the Study

The purpose of the study is to contribute to the coordinated development, management, and use of the water, land, and related resources of the island of Hawaii. The primary objectives of the study are to: (1) identify present and potential land and water resource problems and opportunities for solving them; (2) provide a basis for more effective coordination of USDA programs with the related activities of other federal, state and local agencies; and (3) provide a sound basis for the development of water and related land resources by means of Public Law 83-566 projects or other U.S. Department of Agriculture programs.

The report includes: (1) an inventory of natural resources; (2) an analysis and projections of economic development; (3) a description of the causes and extent of the island's resource problems; (4) an indication of present and future needs for resource conservation and development; (5) a discussion of existing resource projects and programs; (6) a description of the resource development potential; (7) an indication of the opportunities for development under USDA programs; and (8) suggested future programs and coordination needs among all groups and agencies.

The Water Resources Council's Principles and Standards were not applicable to this study since it was so far advanced when they were adopted. The formulation of alternative plans was not included as a part of the study.

Description of the Study Area

Hawaii is the southeasternmost and largest island of the Hawaiian Archipelago (Figure 1.1). Commonly referred to as the Big Island, Hawaii has a total land area of 4,038 square miles, or 2,584,320[1/] acres, nearly two-thirds of the state's total land area.

The County of Hawaii, which encompasses the entire island, had a population of 63,468 in 1970. Hilo, the county seat and commercial center, had a population of 26,353.[2/] The rest of the population is distributed among the small villages scattered along the coastal fringes of the island.

Landownership on the island is highly concentrated with 40 owners controlling 93 percent of the island; the remaining 7 percent is held by many

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1/ Dept. of Planning & Economic Development, The State of Hawaii Data Book 1974. Nov. 1974.

2/ U.S. Bureau of the Census, U.S. Census of Population: 1970.

small private landowners. Public ownership (state and federal) amounts to 52 percent of the total island area. Thirty-eight large private ownerships (over 1,000 acres) account for nearly 41 percent of the total.

Agricultural production on the island is geographically concentrated by major products. The Hamakua, Hilo, and Ka'u areas produce most of the sugarcane, while the Kona area produces all of the coffee. All areas except Kohala produce large amounts of macadamia nuts. Vegetable production is most significant in the Waimea, Hilo, Kona and Volcano areas. All areas produce cattle with the largest numbers in the Kohala, Kona, and Ka'u sub-basins. Although agriculture is an important economic activity, the tourist industry has grown substantially and is expected to be the primary source of economic growth in about 10 years.

Almost half of the island is forest or brush-covered. Large parts of the forest land are vital watershed areas. Endemic flora and fauna are of great scientific interest. Hawaii's forests provide many opportunities for recreation activities, including hunting, besides providing the scenic back-drop which helps make the island attractive. Timber production is not a major enterprise but more than 700,000 acres of forest land have soils and climate suited for the production of timber crops.

Problems and Needs

Flooding is a serious, widespread problem on the island. An estimated 13,300 acres throughout the island are subject to floodwater and sediment damage from overland runoff and stream overflow. Flood-prone areas are often difficult to recognize. Most of the flood prevention efforts to date have corrective-type actions.

Construction in flood-prone areas is increasing the potential for flood damage. Emphasis must be placed on preventing future flood problems. Construction in flood plains and alteration of the natural terrain should be carefully planned and controlled to avoid creation of additional overland flooding problems.

Sheet and gully erosion are problems on the steeply sloping cropland, especially in the Hamakua, Hilo, Ka'u, and Kona areas. Wind erosion affects both cultivated and grazing lands in the drier Kohala areas. Nearly 141,000 acres on the island are affected by erosion damage problems. Although only 33 percent of this acreage needs cooperative action to alleviate the problem, the large acreage with erosion problems indicates the great need for conservation measures on individual farms.

Steep rainfall gradients and the uneven rainfall distribution results in abundant water overall, but with great surpluses in some areas and deficiencies in others. Water deficiency problems are largely centered in the western coastal area, which has almost no usable quantities of surface water, and only brackish groundwater at lower elevations. Periodic droughts inflict severe economic losses because most cropland and all pastureland are unirrigated. Records indicate the probability of a serious drought occurring somewhere on the island during any given 10-year period exceeds 90 percent.

While most forest lands are in good hydrologic condition, problems affecting water and other forest resources in some areas result from careless land clearing, feral animals, insects, disease, noxious plant pests, wildfire, and improper road location and maintenance. Coincident with the need for greater efforts to solve these problems is the need for more intensive management of forest lands to provide increased goods and services to meet the needs of a growing population.

Development of water, land and related resources is needed to improve standards of living, economic opportunities, and well-being of people on the island. These developments include: (a) land treatment for protection and maintenance of soil and water resources; (b) flood prevention and flood plain management in flood hazard areas; and (c) recreational and fish and wildlife habitat areas.

Findings and Conclusions

In the past decade (1960-1970), a trend of population decline reversed and the island's population increased by about 2,000 persons, and is projected at 87,000 in 1980, a 38 percent increase. Major population growth areas are expected to be the South Hilo, South Kohala, and North Kona districts which house the bulk of the tourist industry development. Population in the other predominantly agricultural areas is expected to remain relatively stable or increase slightly.

With the exception of coffee, agricultural output is projected to increase by 1980 with major gains in macadamia nut, papaya, and beef production. In most cases, the recorded gains are expected to be accomplished through expansion in acreage, yield increases due to improved technology and management, and application of needed soil and water conservation measures to reduce losses caused by flooding and erosion.

Due to the relatively small size of the study area, derivation of reliable estimates of agricultural land use and production for the year 2020 is not feasible. However, estimates on existing trends indicate increased production; substantial increases in fruit acreages; and relatively stable acreages in vegetables, grazing, and sugar. In the face of rising demand, limited area of productive land, and the high cost of labor and materials, the need for exploring economically sound opportunities in yield-increasing technology is apparent. The economic feasibility of increased irrigation should be investigated.

The forest lands have potential for providing increased products and services for environmental, economic and social needs. Hawaii's diverse forest environments offer excellent potential for increased recreation use and a well developed system of roads, trails, and other improvements will provide increased recreation opportunities. The development and growth of a local wood products industry can help expand the island's economic base. Although Hawaii's forests now produce less than 3 percent of the state's wood products needs, the physical potential to grow timber crops in Hawaii far exceeds the volume imported. Yields of usable water can be improved through

more intensive management in critically important water source areas. Flood runoff and erosion can be reduced by decreasing the intensity of grazing on steep forested watersheds. In other areas, forage can be increased for both domestic and game animals.

USDA programs can improve the conservation, development, and use of the island's land and water resources. These programs emphasize proper land use and management and the application of land treatment and conservation measures to reduce runoff, erosion, sedimentation, and flood damages. The island's topographic and geologic conditions severely limit development of water impoundments that could also provide recreational, fish and wildlife, and environmental enhancement benefits. In addition to the lack of suitable water storage sites, the control of most of the cropland by large corporate plantations also limits the opportunities for providing irrigation water developments by project action under USDA programs.

One potential watershed was found to be feasible for project action under PL-566. Measures in this watershed will include land treatment practices, floodwater diversions, and channel work to alleviate floodwater, sediment, and erosion damages. Planning assistance under PL-566 has been approved for this watershed.

Identification of flood prone areas can also be undertaken through the Flood Hazard Analyses Program authorized under PL-566. Cooperative studies with the state and local governments are needed to identify flood prone areas for the purpose of flood plain management. In the South Kohala, Kona and Ka'u areas which are under pressure for resort and residential development, flood plain management offers the best hope of preventing flood losses.

Information, technical assistance, and cost sharing programs should be intensified throughout the island. The purposes of these programs are to help control erosion and sedimentation and to encourage sound management practices including measures needed to enhance environmental quality on all agricultural and forest lands.

Increased conservation treatment and management of the agricultural lands is a continuing and important need throughout the island. About 94,800 acres, or 65 percent of the total cropland, needs intensive treatment such as terraces, diversions, grassed waterways, stripcropping and block planting in addition to management needs such as residue management and fertility maintenance. Such a program of assistance would enable land owners and operators to accelerate the installation of conservation measures and expedite compliance with State Water Quality Standards.

USDA agencies, other federal and state agencies, and private landowners are helping to alleviate many problems related to the conservation and wise use of water and land resources. There are opportunities to accelerate current programs in solving island problems. Many problems can be solved through individuals and groups, but the best use of all resources requires development under a coordinated and cooperative program.

I. INTRODUCTION

Description of the Study Area

Lying near the northern margin of the tropics, the island of Hawaii ("Big Island") is the largest and southeasternmost of the Hawaiian Islands (Figure 1.1). It is 93 miles long, 76 miles wide, and has 313 miles of shoreline. Its land area of 4,038 square miles (2,584,320 acres) constitutes 63 percent of the state's total land area. Hawaii is also, geologically, the youngest island and was formed by five volcanoes; two of which, Mauna Loa and Kilauea, are still active.

A great diversity of climatic conditions occurs and the island's terrain includes tropical rain forest, productive cropland, misty plateaus, semi-arid grazing land, and a barren lava desert. The central mountains dominate the island, and their domelike structures cause drainage to follow a radial pattern with little branching to form tributary systems of streams, lakes, and rivers. Thus, the island has many narrow independent drainage basins consisting of only one principal relatively short stream.

Hawaii County, occupying the entire island of Hawaii, is particularly suited for industries with extensive land requirements. Agriculture is a major source of revenue with sugar production, cattle ranching, and diversified agriculture the principal industries. The Big Island leads the state's production of raw sugar; more than 431,000 tons were produced in 1970, about 40 percent of the state total. It also produces more than half the beef, about 99 percent of the macadamia nuts, and about 48 percent of the fruits and vegetables grown in the state. In addition, Hawaii County is the only producer of coffee in the United States.

The tourist industry has grown substantially and has been the dominant factor in the island's recent economic growth. The Big Island's national parks are outstanding attractions and were visited by over one million people in 1970. Moreover, its shorelines and mountains provide year-round opportunities for practically all outdoor pursuits. Visitor expenditures are expected to be the most important source of economic growth and the primary economic stimulant in the years to come.

Need for the Study

During the past few decades, the island of Hawaii has had its economic ups and downs. Population of the island declined from more than 73,000 in 1940 to a low of about 60,000 in the mid-'60s. Having a predominantly agricultural economy for many years, the island has retained a rural atmosphere with population sparse in relation to land area. However, rapid changes are occurring as a growing tourist industry has spurred widespread and varied development.

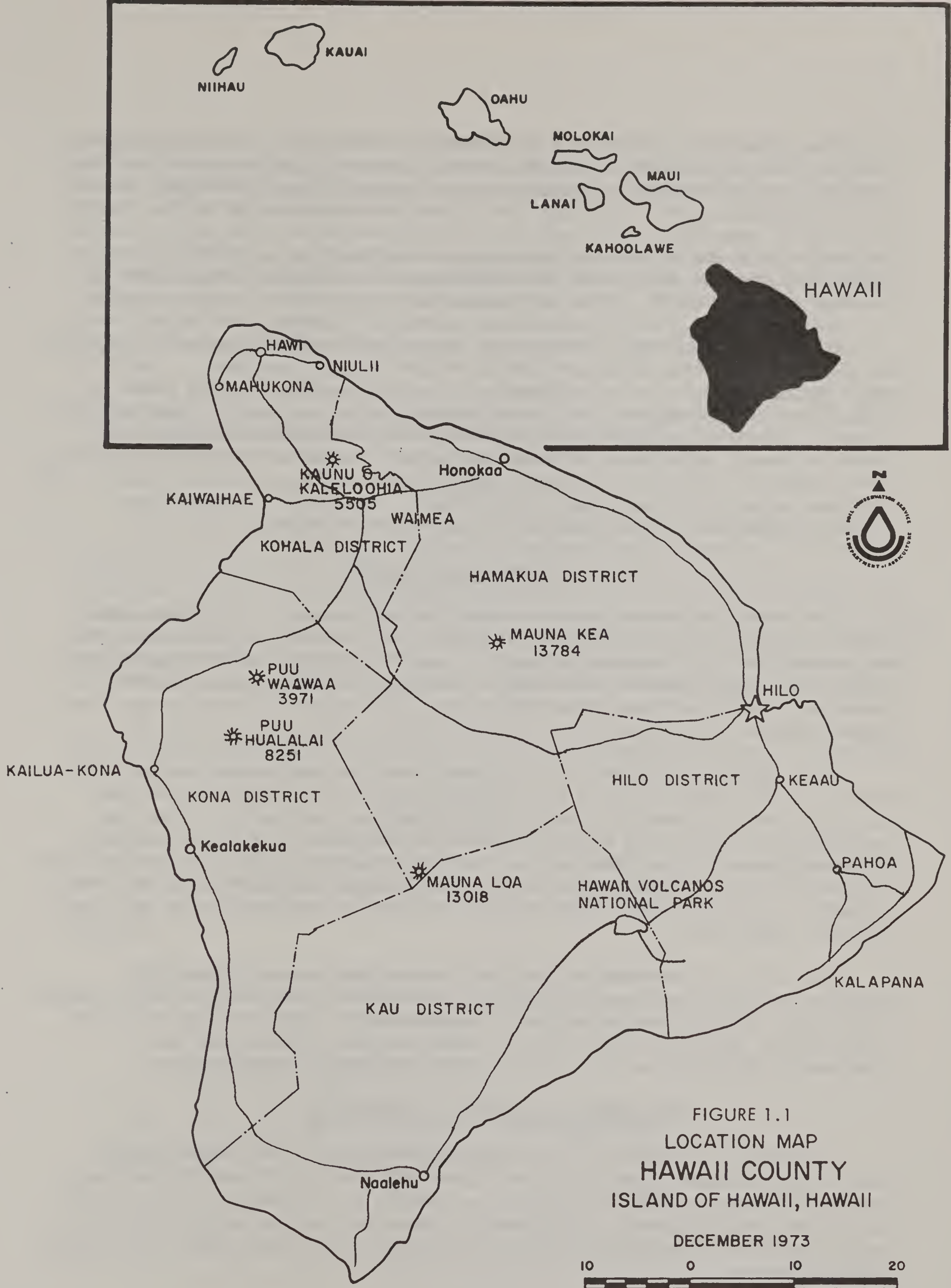


FIGURE 1.1

LOCATION MAP

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

DECEMBER 1973

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1974

M7-L-22695

The island is subject to high intensity rainstorms that often generate flash floods which erode fields and cause extensive floodwater and sediment damages. As development progresses in the coastal areas, flooding becomes an increasing problem. Although the island receives some 10 to 300 inches of rainfall annually, water supply problems also occur. The highly uneven rainfall distribution and the great annual variability in rainfall lead to great surpluses in some areas and deficiencies in others. While there is abundant water overall, its distribution is a major water supply problem.

Orderly development of the water and related land resources is required to meet the short- and long-term needs of the island's residents. Solution of existing problems and a balanced, diversified economy in the years to come cannot be accomplished by the piecemeal efforts of conflicting interest groups. Recognizing the need for coordinated resource development, the State of Hawaii Department of Land and Natural Resources requested that the USDA conduct a survey to provide information on the agricultural, rural, and upstream aspects of the island's watersheds. The state's request was formally supported by the Council of the County of Hawaii.

Authority and Organization

The study was made under the authority of Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 83-566, as amended). The Act authorizes the Secretary of Agriculture to cooperate with other federal, state, and local agencies in making investigations and surveys of the watersheds, of rivers and other waterways, as a basis for developing coordinated programs.

USDA agencies involved in the survey were the Soil Conservation Service, with responsibility for overall leadership, the Forest Service, and the Economic Research Service. The study was carried out under the guidance of a USDA Field Advisory Committee composed of one representative from each agency. The USDA survey staff gathered and evaluated the data and information for the study with each agency having responsibility for certain aspects, as outlined in a plan of work approved by the Washington and Field Advisory Committees.

The Hawaii Department of Land and Natural Resources, through its Division of Water and Land Development, coordinated the USDA planning efforts with state, county, and other local organizations. The division also provided useful data and information on water supply problems and made invaluable contributions by expressing local desires and objectives.

Objectives and Nature of the Study

The survey's purpose is to present information on the agricultural, rural, and upstream aspects of the island and thus contribute to the comprehensive planning needed to produce the orderly development beneficial for the island and its people. Information developed in the survey will help to guide the wise and efficient use of the island's available water and related land resources.

Specifically, the survey inventories agricultural water and related land resources, identifies agricultural and rural community problems and needs, and determines the opportunities for development of the island's water and related land resources.

The survey is a reconnaissance investigation consisting of accumulating and evaluating previously recorded data and making limited studies to gather basic information not otherwise available. These included soil interpretations, computer assembly and mapping of soil and vegetative cover data, hydrologic evaluations, and economic studies and projections.

USDA programs and assistance were emphasized in meeting the objectives. Emphasis was placed on watershed investigations to determine where PL-566 projects were feasible and what their effects would be.

Use of the Report

This report can be used in coordinating USDA resource programs with similar activities of local, state, and other federal agencies. It contains information that public officials and private interests can use in making land use decisions, in determining priorities for installation of works of improvement, and in generally guiding the coordinated development of the Big Island's resources to meet the needs of the local people. Erosion, sediment, and land treatment information may be used as a base for developing conservation programs to satisfy portions of the state's water quality standards.

The basic data used as foundation for most of the statistical information in this report are available at the Soil Conservation Service, Honolulu, Hawaii, and are available to the public.

Acknowledgements

The following federal, state, and local agencies have contributed to this study by supplying data, counsel, and technical help:

Federal

U.S. Department of the Army - Corps of Engineers
U.S. Department of Agriculture -
Agricultural Stabilization and Conservation Service
Farmers Home Administration
Cooperative Extension Service
Statistical Reporting Service
U.S. Department of Commerce - National Weather Service
U.S. Department of the Interior - National Park Service
U.S. Bureau of Outdoor Recreation
U.S. Water Resources Council

State of Hawaii

Department of Planning and Economic Development
University of Hawaii -
Land Study Bureau
Cooperative Extension Service
Agricultural Experiment Station
Legislative Reference Bureau
Department of Hawaiian Home Lands
Department of Health

Hawaii County

Department of Parks and Recreation
Department of Research and Development
Department of Water Supply

II. NATURAL RESOURCES OF THE ISLAND

This section describes the natural resources of the island of Hawaii in both qualitative and quantitative terms. Features most important to water and related land resource development are stressed. Specifically included in the discussion are climate; geology and physiography; land resources, including topography, soils, vegetation, and land use and management; water resources, fish and wildlife resources; and the quality of the environment.

Climate

The island of Hawaii has a warm, semi-tropical climate generally characterized by two seasons a year. It has striking contrasts in rainfall, mild uniform temperatures except at higher elevations, and persistent northeasterly trade winds. The island's mountainous topography modifies the marine influence and produces considerable local variations in its climate. Conditions range from humid and cloudy on the windward coast to arid and semi-arid on the upper mountain slopes and along the leeward coast near Kawaihae.

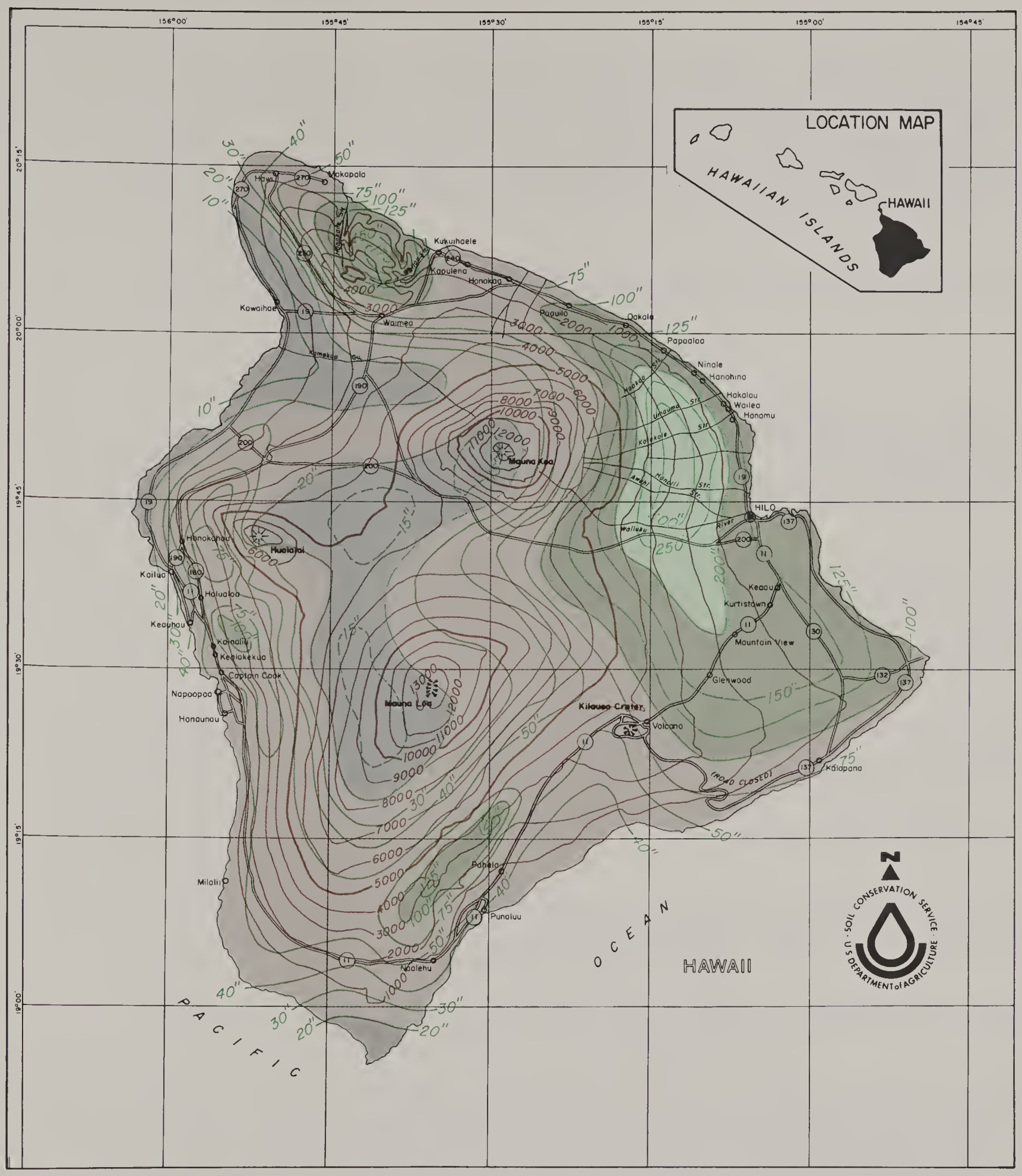
The annual rainfall map (Figure 2.1) illustrates the complexity of the rainfall pattern. The high annual rainfall of 75 to over 300 inches on the windward side of the island shows the effect of the ascending air of the prevailing trade winds. Highest rainfall occurs west of Hilo on the lower slopes (2,000-4,000 feet elevation) of Mauna Kea and Mauna Loa. At the other extreme, annual rainfall averages less than 10 inches near Kawaihae and less than 20 inches on the upper slopes of Mauna Kea and Mauna Loa.

Lowland areas receive most of their rainfall during the winter (October to April) when trade wind showers are supplemented by short duration "kona" or southerly storms. These have produced 30 inches or more in a 24-hour period. However, in the Kona area, sheltered from the trades by Mauna Kea, Mauna Loa, and Hualalai, convective conditions prevail and summers (May through September) are wetter than winters.

The middle elevations (2,000 to 6,000 feet) receive the highest rainfall, distributed fairly uniformly throughout the year. At high elevations rainfall is scant with a slight winter maximum.

Rainfall also is highly variable from year to year with ranges of 300 percent common. For example, Hilo with an average annual rainfall of about 140 inches has experienced extreme annual totals of 72 and 207 inches, and extreme monthly totals of 0.2 inch and 66 inches.

Temperature differences on the island result chiefly from variations in elevation. Average annual temperature at Hilo is 73°F with February being the coolest month at 71° and August, the warmest at 76°. This small annual temperature range is characteristic of the lowlands with leeward locations slightly warmer and more variable. Average daily range in temperature is between 8° and 20°, thus temperatures change more in the



AVERAGE ANNUAL RAINFALL

- Less than 20 inches
- 20 – 100 inches
- 100 – 200 inches
- Greater than 200 inches
- —40"— Average annual rainfall
- —4000— Equal elevation

FIGURE 2.1

AVERAGE ANNUAL RAINFALL
HAWAII COUNTY
ISLAND OF HAWAII, HAWAII

MARCH 1973

10 0 10 20 MILES
SCALE 1:1,000,000

Source: State of Hawaii, Department of Land & Natural Resources, Division of Water & Land Development.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1973

M7-L-22696A

course of an average day than from season to season. Temperatures decrease with elevation, and the 14,000-foot summits of Mauna Kea and Mauna Loa are frequently covered with snow for two months in winter. Average annual temperature at the 11,000-foot level of Mauna Loa is 44°, ranging from 41° in February to 47° in August. Extremes of 22° and 96° have been recorded on the island, but temperatures above 90° and lower than 55° are very unusual in the lowlands.

The moderate range of temperature and daylight hours permits relatively uniform crop growth throughout the year.

Geology and Physiography

Hawaii is geologically the youngest island in the Hawaiian group. It was built from the ocean floor by the lava outpourings from five volcanoes--Kohala, Mauna Kea, Hualalai, Mauna Loa, and Kilauea. The volcanoes are believed to have started in the Tertiary period. Geologic features of the island are shown in Figure 2.2.

The Kohala Volcano on the northern end of the island--5,505 feet high--became extinct in the Middle Pleistocene. It is built largely of olivine basalt with a few thin intercalated beds of vitric basaltic ash. The Kohala Volcano was deeply eroded on the windward side near the end of the Pliocene time.

Mauna Kea, the highest mountain at 13,784 feet above sea level, has not erupted during historic times. It is built up of olivine basalt and covered with layers of volcanic ash. These individual ash layers vary in thickness from less than an inch to about 4 to 5 feet. During the Wisconsin stage of glaciation in North America, Mauna Kea was capped by a glacier about 250 feet thick.

Hualalai Mountain--8,271 feet high--is built up of basalts. Puu Waawaa, a large trachyte pumice cone, lies on the northern slope. The last eruption of Hualalai in 1800-1801 produced olivine basalt.

Mauna Loa covers an area of 2,035 square miles or 50 percent of the island. It is 13,680 feet high and last erupted in 1950.

Kilauea Volcano--4,090 feet high--originated on the southern slopes of Mauna Loa. Its lavas are largely olivine basalt. The flows in recent years have not been of the explosive type, and it has been possible to observe them safely at close range. The most spectacular eruption occurred in 1959 when Kilauea Iki erupted and sent fountains of lava shooting 1,900 feet in the air. The following year a flank eruption engulfed the town of Kapoho. Since then, many eruptions of short duration have occurred along the fissure zone.

The topography of the island reflects the volcanic activity. In northern and eastern sections where volcanic flows have not occurred recently, the terrain has been eroded by rivers and streams. In the southern section the terrain is undissected, quite barren, and reveals large areas of exposed lava.

FIGURE 2.2

NORTH HALF

GENERALIZED GEOLOGY

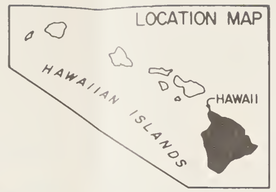
HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

SEPTEMBER 1973

5 0 5 10 MILES

SCALE 1:400,000



SEDIMENTARY ROCKS

PLEISTOCENE and RECENT

Hl — Landslides and Mudflows (1868)

Qa — Unconsolidated and Consolidated Alluvium and Talus

IGNEOUS ROCKS

	HUALALAI	KOHALA MOUNTAINS	MAUNA LOA	KILAUEA	MAUNA KEA
RECENT — HISTORIC — HUALALAI VOLCANIC SERIES	Hh Historic Member (1800 to 1801)		Hm Historic Member (1832 to 1942)	Hk Historic Member (1750 to 1934)	
RECENT — HUALALAI VOLCANIC SERIES	Qh Prehistoric Member		Qk Prehistoric Member	Qp Prehistoric Member	
PLEISTOCENE	Pw Waawaa Volcanics	Phl Hawi Volcanic Series	Pk Kohuku Volcanic Series	Ph Hilina Volcanic Series	Pm Hamakua Volcanic Series
PLIOCENE		GREAT EROSIONAL UNCONFORMITY			
PLIOCENE		Tp Pololu Volcanic Series	Tn Ninole Volcanic Series		

LAUPAHOEHOE VOLCANIC SERIES: Rk Upper Member; Pl Lower Member

TERTIARY and QUATERNARY

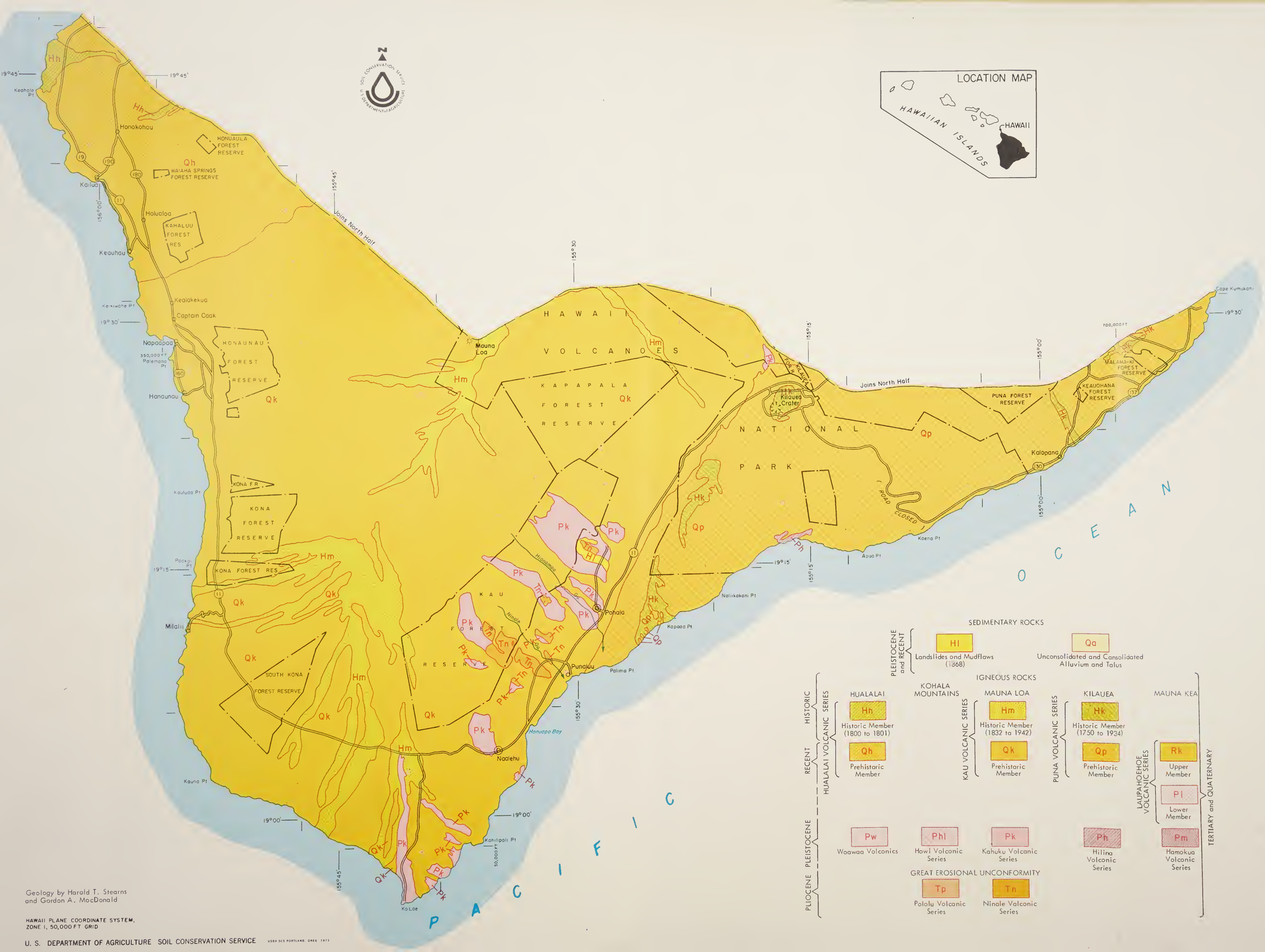
U.S. DEPARTMENT of AGRICULTURE · SOIL CONSERVATION SERVICE

Geology by Harold T. Stearns and Gordon A. MacDonald

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USSA SCS PORTLAND OREG 1973

North Half
M7-E-22697A-N



SEDIMENTARY ROCKS

PLEISTOCENE and RECENT	Hl — Landslides and Mudflaws (1868)	Qa — Unconsolidated and Consolidated Alluvium and Talus

IGNEOUS ROCKS

		KOHALA MOUNTAINS	MAUNA LOA	KILAUEA	MAUNA KEA
RECENT — HISTORIC	HUALALAI VOLCANIC SERIES	HUALALAI			
		Hh — Historic Member (1800 to 1801)	Hm — Historic Member (1832 to 1942)	Hk — Historic Member (1750 to 1934)	
		Qh — Prehistoric Member	Qk — Prehistoric Member	Qp — Prehistoric Member	
PLIOCENE PLEISTOCENE		Pw — Waawaa Volcanics	Phl — Howi Volcanic Series	Pk — Kahuku Volcanic Series	Ph — Hilina Volcanic Series
					Rk — Upper Member
					Pl — Lower Member
					Pm — Hamakua Volcanic Series

GREAT EROSIONAL UNCONFORMITY

Tp — Pololu Volcanic Series

Tn — Ninole Volcanic Series

TERTIARY and QUATERNARY

FIGURE 2.2

SOUTH HALF

GENERALIZED GEOLOGY

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

SEPTEMBER 1973

5 0 5 10 MILES

SCALE 1:400,000

Geology by Harold T. Stearns and Gordon A. MacDonald

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND, OREG. 1973

South Half
M7-E-22697A-N

The valleys draining the rainy windward slopes of Mauna Kea are smaller than those of Kohala Mountain. The difference in size results from the greater age of the valleys on Kohala. The dry western slope of Mauna Kea is largely undissected by stream erosion. The prominent gulches in the upper slopes of Mauna Kea have a distinct relationship to the glaciers which covered the top of the mountain during the late Pleistocene time. Shallow gulches drain the southwestern slopes of Mauna Loa.

The Waimea Plain resulted from the Mauna Kea lava ponding against the older Kohala Mountain. The plain is covered with volcanic ash. The Interior Plateau at Pohakuloa is covered with recent lava from Mauna Loa banking against Mauna Kea and Hualalai.

Wave actions have eroded the basic rock and formed high sea cliffs that extend along the entire windward coast from Hilo to Kohala. These nearly vertical cliffs range from 50 to 350 feet in height. Along the leeward coast where there is less wave action, cliffs stand less than 30 feet in height.

Bays and sandy beaches are scarce along the rugged coastline. Hilo, Kailua, and Kawaihae are the largest bays. Black sand beaches occur along the southeast coast and a few scattered coral sand beaches are found on the western side.

Land Resources

Soils

Seventy soil series and twelve miscellaneous land types have been described and mapped in Hawaii County. The 70 soil series were combined into 13 great groups of the Soil Taxonomy in the report; and the twelve miscellaneous land types into three groups. These 16 units are displayed on the Great Group Soil Map, Figure 2.3.

The 13 great groups fall into the following five orders:

Entisols - Recent soils and very steep soils that lack distinctive horizons.

Inceptisols - Young but not recent land surfaces with weakly developed horizons.

Aridisols - Generally dry soils.

Mollisols - Dark-colored soils with high amount of bases.

Histosols - Organic soils.

An order represents the kind and relative strength of the soil forming process as expressed in different kinds of soil horizons. However, it is so broad that the soils in it have only general similarities in morphology and in genetic relationship.

GREAT GROUP SOIL

ENTISOLS: RECENT SOILS THAT HAVE NOT WEATHERED SUFFICIENTLY TO FORM HORIZONS.

USTORTHENTS: Coarse textured, somewhat excessively drained soils.

INCEPTISOLS: USUALLY MOIST SOILS ON YOUNG BUT NOT RECENT LAND SURFACES WITH WEAKLY DEVELOPED HORIZONS.

DYSTRANDEPTS: Well-drained volcanic ash soils with low inherent fertility.

EUTRANDEPTS: Well-drained volcanic ash soils with high inherent fertility.

HYDRANDEPTS: Well-drained volcanic ash soils with low inherent fertility that dehydrate irreversibly into gravel and sand-sized aggregates.

VITRANDEPTS: Somewhat excessively drained, coarse textured, volcanic ash soils with medium to high inherent fertility.

PLACANDEPTS: Somewhat poorly drained volcanic ash soils with thin, discontinuous, cemented ironstone pan that restricts water movement and root development.

ANDAQUEPTS: Somewhat poorly drained volcanic ash soils.

PLACAQUEPTS: Poorly drained basaltic soils with thin, cemented ironstone pan that restricts water movement and root development.

HUMITROPEPTS: Well-drained soils with low inherent fertility and high organic matter content.

USTROPEPTS: Usually dry, well-drained soils with medium inherent fertility.

ARIDISOLS: USUALLY DRY SOILS WITH LOW ORGANIC MATTER CONTENT.

CAMBORTHIDS: Somewhat excessively drained, stony or rocky soils developed in volcanic ash on coastal plains.

MOLLISOLS: USUALLY MOIST SOILS WITH DARK-COLORED SURFACE HORIZON AND HIGH BASES.

HAPLUSTOLLS: Usually dry, well-drained stony soils on low leeward mountain slopes.

HISTOSOLS: ORGANIC SOILS

TROPOFOLIST: Well-drained, very shallow organic soils underloin by aa lova (Typic) or pahoehoe lava (Lithic).

GEOLOGIC LANDFORMS: FORMATIONS WITH NO SOIL MATERIAL OR TOO LITTLE SOIL TO BE RECOGNIZED AS A SOIL SERIES.

LAVA FLOWS, AA. VERY STONY LAND, CINDER LAND: Mostly barren aa lova flows, very shollow volcanic ash over aa lovo, and cinder cones.

LAVA FLOWS, PAHOEHOE. ROCKLAND: Mostly barren pahoehoe lavo flow, and very shollow volcanic ash over pahoehoe lova.

MISCELLANEOUS LAND TYPES: LAND THAT HAS LITTLE OR NO NATURAL SOIL OR THAT IS TOO INACECESSIBLE FOR ORDERLY EXAMINATION.
Includes Amalu - Rough broken lond associotion;
Hydrondepts - Tropofolists association;
Tropaquepts, beoches, fill lond, mixed olluviol lond, and rough broken lond.

Each oreo outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than o basis for decisions on the use of specific tracts.

FIGURE 2.3
NORTH HALF
GREAT GROUP SOIL MAP
HAWAII COUNTY
ISLAND OF HAWAII, HAWAII
OCTOBER 1973

5 0 5 10 MILES
SCALE 1:400,000

AWAII PLANE COORDINATE SYSTEM,
ONE I, 50,000 FT GRID

S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OREG 1973

North Half
M7-EN-22697B

LOCATION MAP
HAWAIIAN ISLANDS
HAWAII
Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.
GREAT GROUP SOIL
ENTISOLS: RECENT SOILS THAT HAVE NOT WEATHERED SUFFICIENTLY TO FORM HORIZONS.
USTORTHENTS: Coarse textured, somewhat excessively drained soils.
INCEPTISOLS: USUALLY MOIST SOILS ON YOUNG BUT NOT RECENT LAND SURFACES WITH WEAKLY DEVELOPED HORIZONS.
DYSTRANDEPTS: Well-drained volcanic ash soils with low inherent fertility.
EUTRANDEPTS: Well-drained volcanic ash soils with high inherent fertility.
HYDRANDEPTS: Well-drained volcanic ash soils with low inherent fertility that dehydrate irreversibly into gravel and sand-sized aggregates.
VITRANDEPTS: Somewhat excessively drained, coarse textured, volcanic ash soils with medium to high inherent fertility.
PLACANDEPTS: Somewhat poorly drained volcanic ash soils with thin, discontinuous, cemented ironstone pan that restricts water movement and root development.
ANDAQUEPTS: Somewhat poorly drained volcanic ash soils.
PLACAQUEPTS: Poorly drained basaltic soils with thin, cemented ironstone pan that restricts water movement and root development.
HUMITROPEPTS: Well-drained soils with low inherent fertility and high organic matter content.
USTROPEPTS: Usually dry, well-drained soils with medium inherent fertility.
ARIDISOLS: USUALLY DRY SOILS WITH LOW ORGANIC MATTER CONTENT.
CAMBORTHIDS: Somewhat excessively drained, stony or rocky soils developed in volcanic ash on coastal plains.
MOLLISOLS: USUALLY MOIST SOILS WITH DARK-COLORED SURFACE HORIZON AND HIGH BASES.
HAPLUSTOLLS: Usually dry, well-drained stony soils on low leeward mountain slopes.
HISTOSOLS: ORGANIC SOILS
TROPOFOLIST: Well-drained, very shallow organic soils underlain by aa lava (Typic) or pahoehoe lava (Lithic).
GEOLOGIC LANDFORMS: FORMATIONS WITH NO SOIL MATERIAL OR TOO LITTLE SOIL TO BE RECOGNIZED AS A SOIL SERIES.
LAVA FLOWS, AA. VERY STONY LAND, CINDER LAND: Mostly barren aa lava flows, very shallow volcanic ash over aa lava, and cinder cones.
LAVA FLOWS, PAHOEHOE. ROCKLAND: Mostly barren pahoehoe lava flow, and very shallow volcanic ash over pahoehoe lava.
MISCELLANEOUS LAND TYPES: LAND THAT HAS LITTLE OR NO NATURAL SOIL OR THAT IS TOO INACCESSIBLE FOR ORDERLY EXAMINATION.
Includes Amolu - Rough broken land association;
Hydrandepts - Tropofolists association;
Tropaquepts, beaches, fill land, mixed alluvial land, and rough broken land.
HAWAII PLANE COORDINATE SYSTEM, ZONE I, 50,000 FT GRID
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
Honokohau
Kailua
Holualoa
Keauhou
Kealakekua
Captain Cook
Napoopoo
Honaunau
Milolii
Mauna Loa
Kilauea Crater
Kalapana
Pahala
Punaluu
Naalehu
Ka Lae
HONAUNAU FOREST RESERVE
KONA FOREST RESERVE
SOUTH KONA FOREST RESERVE
KAU FOREST RESERVE
KAPAPALA FOREST RESERVE
HAWAII VOLCANOES NATIONAL PARK
PUNA FOREST RESERVE
Joins North Half
PACIFIC OCEAN
FIGURE 2.3
SOUTH HALF
GREAT GROUP SOIL MAP
HAWAII COUNTY
ISLAND OF HAWAII, HAWAII
OCTOBER 1973
SCALE 1:400,000
5 0 5 10 MILES
South Half
M7-EN-22697B

The great groups are separated on the basis of uniformity in kind and sequence of genetic horizons, on factors that influence inherent fertility, and on properties related to climate. The genetic factors of the great groups on the island of Hawaii are shown in Table 2.1. The 13 great groups and one miscellaneous land type are described as follows:

Ustorthents - These soils developed on deposits of recent volcanic activity. There is little or no evidence of distinctive horizons. They are somewhat excessively drained, coarse-textured soils with low organic matter content, low available water capacity, and low inherent fertility.

Dystrandepts - These soils developed from volcanic ash, have high organic matter content, and low to medium inherent fertility. They are well-drained, moderately fine to coarse-textured soils with moderate to high available water capacity.

Eutrandepts - These soils developed from volcanic ash, have medium organic matter content and high inherent fertility. These soils are well-drained, medium to moderately coarse-textured soils with moderate available water capacity.

Hydrandepts - These soils developed from volcanic ash, have high organic matter content, low inherent fertility, and dehydrates irreversibly into sand and gravel-size aggregates. They are well-drained to moderately well-drained, moderately fine-textured soils with high available water capacity.

Vitrandepts - These soils have low organic matter content, medium to high inherent fertility, and large amounts of vitric ash and pumice. They are well to somewhat excessively drained, moderately coarse to coarse-textured soils with low to moderate available water capacity.

Placandepts - These soils developed from volcanic ash, have a thin, discontinuous, cemented ironstone pan that restricts water movement and root development. Water commonly saturates much of the soil above the pan for variable periods. They are somewhat poorly drained, moderately fine-textured soils with high available water capacity.

Andaquepts - These are wet volcanic ash soils. Ground water stands close to the surface at some time during the year. They are somewhat poorly drained, moderately fine-textured soils.

Placaquepts - These soils are wet Inceptisols that have a thin, discontinuous, cemented ironstone pan that restricts water movement and root development. They are poorly drained, fine-textured soils developed in basic igneous rock.

Humitropepts - These are soils without significant amounts of active amorphous clay or pyroclastic material; however, they have high organic matter content and low inherent fertility. They are well-drained, moderately fine-textured soils with moderate available water capacity.

Ustropepts - These are soils without significant amounts of volcanic ash material in a dry and hot area. They are well-drained, moderately fine-textured soils with moderate available water capacity, medium organic matter content, and medium to high inherent fertility.

Camborthids - These are soils that have no water available to mesophytic plants for prolonged periods. In addition, they have an altered horizon having a loamy-fine sand or finer texture. They are somewhat excessively well-drained, moderately coarse-textured soils with moderate available water capacity and low organic matter content.

Haplustolls - These are soils with a dark colored, soft surface horizon and moderate to high inherent fertility. They are well-drained, moderately fine-textured soils with low available water capacity and low organic-matter content.

Tropofolists - These are very shallow organic soils underlain by fragmental aa or pahoehoe lava flows. Although occurring in subhumid to very humid areas, these soils are never saturated with water for more than a few days following heavy rains. They have low inherent fertility.

Miscellaneous Land Types - Miscellaneous land types are used for areas that have little or no evidence of soil formation or in areas too inaccessible for orderly examination. They include the Amalu-Rough Broken Land association, Tropaquepts and Hydrandepts-Tropofolist, and aa and pahoehoe lava flows.

Agricultural Interpretations - The use of soils for crops and pasture is affected by the nature of the soils, the climate, and the management it receives. The 13 great groups are subdivided into subgroups and families because of the wide variety of soils included at the great group level. The families provide for more precise interpretations since they include soils with similar properties important to the growth of plants. Therefore, the nature of each soil within a family was evaluated for its agricultural capability.

The soils within a family are likely to differ in some properties; for example, slope, depth, stoniness, or rockiness. Therefore, the ratings were based on the most limiting phase of the family if it occupies more than one-third of the area. However, if the most limiting phase occupies less than one-third of the area, the most extensive phase controlled the rating.

Table 2.2 shows the land capability classification and the soil limitations of each family when used for agriculture. The land capability classification and the soil limitation ratings are briefly described.

Table 2.1. Genetic Factors of the Great Groups

Great Group	Former Classification	Position	Elevation (ft.)	Rainfall (in.)	Soil Temp. (deg.)	Acreage		Major Land Use
						Acres	% of County	
Ustorthents	Regosols	Low to intermediate leeward mountain slopes	200-4000	20-60	68	11,200	<1	Recreation
Dystrandepts	Latosolic Brown Forest Humic Latosols	Low to mountain slopes	0-8000	30-120	53-72	180,900	7	Pasture, sugarcane, woodland
Eutrandepts	Reddish Prairie Reddish Brown	Low to intermediate, leeward mountain slopes	0-6000	25-90	60-74	140,500	6	Pasture, wildlife
Hydrandepts	Hydrol Humic Latosols Latosolic Brown Forest	Low to high mountain slopes	0-6500	80-200	57-73	269,000	10	Sugarcane, woodland
Vitrandepts	Alluvial Latosolic Brown Forest Reddish Prairie Regosols	High mountain slopes and alluvial plains	1000-8000	15-40	47-63	86,000	3	Wildlife, pasture
Placandepts	Hydrol Humic Latosols	Intermediate mountain slopes	3500-4000	60-100	58	12,200	<1	Woodland, pasture
Andaquepts	Humic Latosols	Low windward mountain slopes	1700-2500	100-150	68	3,300	<1	Pasture, woodland
Placaquepts	Hydrol Humic Latosols	High windward mountain slopes	3700-5500	90-250	56	12,200	<1	Watershed, wildlife
Humitropepts	Humic Latosols Low Humic Latosols	Low windward mountain slopes	0-1500	40-90	70-73	18,000	<1	Sugarcane
Ustropepts	Low Humic Latosols	Low windward mountain slopes	0-1200	25-40	73	12,200	<1	Pasture
Camborthids	Red Desert	Low leeward mountain slopes	0-1500	5-20	76	29,000	1	Pasture
Haplustolls	Low Humic Latosols	Low leeward mountain slopes	0-550	20-30	74	3,400	<1	Pasture
Tropofolists	Lithosols	Low to high mountain slopes	0-7000	40-150	54-73	534,000	20	Woodland
Miscellaneous Land Types	Miscellaneous Land Types	Variable	0-13000	5-100	-	1,272,420	9	Woodland, idle

Table 2.2. Major Land Categories by Capability Class and Subclass (Acres). Island of Hawaii, 1967.

Class and Subclass*	Cropland	Pasture	Forest	Other	Total	Percent of Total Area
I	3,100	600	-	-	3,700	-
II	1,700	-	-	-	1,700	-
e	1,700	-	-	-	1,700	
III	25,500	54,500	87,700	6,000	173,700	7
e	25,500	54,500	75,600	4,500	160,100	6
s	-	-	12,100	1,500	13,600	1
IV	50,100	106,600	95,700	6,000	258,400	11
e	49,300	77,700	87,400	3,600	218,000	9
w	100	-	-	2,400	2,500	
s	700	300	8,300	-	9,300	
c	-	28,600	-	-	28,600	1
VI	45,400	240,100	710,700	146,600	1,142,800	49
e	18,700	23,500	6,500	3,500	52,200	2
w	-	6,000	9,100	-	15,100	1
s	26,700	210,600	695,100	143,100	1,075,500	46
VII	-	66,700	69,300	25,500	161,500	7
e	-	6,000	-	-	6,000	
w	-	-	69,300	-	69,300	3
s	-	60,700	-	25,500	86,200	4
VIII	-	-	56,600	557,700	614,300	26
e	-	-	-	40,600	40,600	2
s	-	-	56,600	517,100	573,700	24
Total	125,800	468,500	1,020,000	741,800	2,356,100	

Total inventoried land 2,356,100

Non-inventoried land:
Federal land 201,900
Urban & built-up area . . . 21,000
Total non-inventoried land 222,900

Total island area** 2,579,000

*No land in the state of Hawaii is categorized as Class V.

**Because of differences in definitions and sources, acreage figures differ somewhat from corresponding figures elsewhere in report.

Source: 1967 Hawaii Conservation Needs Inventory.

Land Capability Classification - The land capability classification is an interpretive grouping made primarily for agricultural purposes. The classification groups individual soils into different categories primarily on their ability to produce common cultivated crops and pasture plants without soil deterioration over a long period of time.

The broadest category places all soils in eight capability classes. These are arranged from Class I to Class VIII. The numerals indicate progressively greater limitations in soil use and risks of soil damage.

In general, the classification can be divided into two major divisions: (1) Class I through IV - land suited for cultivation and other uses; and (2) Class V through VIII - land generally not suited for cultivation. A short description of the eight capability classes is as follows:

Class I - Soils have few limitations that restrict their use.

Class II - Soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III - Soils have severe limitations that reduce the choice of plants or require moderate conservation practices.

Class IV - Soils have very severe limitations that restrict the choice of plants, require very careful management or both.

Class V - Not used in the state of Hawaii.

Class VI - Soils have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture, woodland or wildlife.

Class VII - Soils have very severe limitations that make them unsuited for cultivation and that restrict their use largely to pasture, woodland or wildlife.

Class VIII - Soils and land forms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or aesthetic purposes.

Capability subclasses are soil groups within one class; they are designated by adding a small letter, e, w, s, or c, to the class numeral; for example, IIe. The letter e shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation; s shows that the soil is limited mainly because it is shallow, droughty, or stony; and c shows that the chief limitation is climate that is too dry.

With information about location and extent of different kinds of soils, the capability grouping makes it possible to generally appraise the quality of the soil resources of any part of the island, and the treatment needed to sustain or improve them. Many of the natural limitations or hazards can be corrected or overcome by proper treatment and management.

Table 2.2 shows major land categories on the island of Hawaii by land capability classes and subclasses. The table indicates the following distribution of the island's total area: 5 percent cropland, 18 percent pastureland, 39 percent forest land and woodland, 29 percent other land, 8 percent federal lands, and 1 percent urban and built up areas.

The major proportion, or 64 percent, of the cropland is on land capability classes I through IV with the remainder on class VI land. Three-fourths of the pasture is class IV and VI land with the rest about equally distributed on class III and VII land. Seventy percent of the forest land is class VI land with the remainder distributed equally among land capability classes III, IV, VII and VIII.

Soil Limitation for Cropland - Cropland is land used primarily for the production of adapted, cultivated, and close-growing crops. This includes sugarcane and truck crops such as lettuce, carrots, tomatoes, etc.

Soils have limitations in their capacity to produce crops, depending on their inherent characteristics such as depth, texture, slope, stoniness, and others. The soils in each family were rated on their limitation for crop production with irrigation and without irrigation. These soil limitations were expressed in terms of the degree of soil limitation--slight, moderate, or severe. The degree of limitation indicates the severity of the problems that can be expected. For soils with moderate or severe ratings, the major limiting factors are also shown in Table 2.3. The three degrees of soil limitations are defined as follows:

Slight - These soils have few, if any, soil limitations for cropland. A minimum of conservation practices is required.

Moderate - These soils have one or more properties that limit their use for cropland. This limitation may be overcome by special measures or treatment. They require more extensive conservation practices and careful management.

Severe - These soils have one or more properties that seriously affect crop production. They are generally unsuited to cultivation.

Table 2.3. Agricultural Interpretations of the Soil Groups

Soil Groups	Acres	Land Capability Class and Subclass	Soil Limitations for Cropland		Major Land Uses
			Without Irrigation	With Irrigation	
USTORTHENTS Typic Ustorthents Ashy-skeletal, isothermic family	11,200	VIIIs	Severe Extremely gravelly sand; Low moisture	Severe Extremely gravelly sand	Wildlife
DYSTRANDEPTS Typic Dystrandepts Medial, isomesic family	65,900	IVe	Severe High moisture	Moderate Slopes	Pasture Woodland Wildlife
Hydric Dystrandepts Thixotropic over fragmental isothermic family	5,200	VIIs	Severe Extremely stony	Severe Extremely stony	Pasture Woodland Wildlife
Thixotropic isohyperthermic family	11,300	IVe	Moderate High moisture	Slight	Sugarcane
Thixotropic isomesic family	45,400	IVe	Moderate High moisture	Slight	Pasture Woodland Wildlife
Medial, isothermic family	2,600	IIIe	Moderate Bedrock, 20 to 40 inches	Moderate Bedrock, 20 to 40 inches	Pasture Woodland Wildlife
Thixotropic, isothermic family	3,000	VIe	Severe Slopes	Severe Slopes	Sugarcane
Thixotropic, isomesic family	7,900	VIIs	Severe Extremely stony	Severe Extremely stony	Pasture Wildlife
Thixotropic, isothermic family	14,500	IVe	Moderate High moisture	Slight	Sugarcane

Table 2.3. Agricultural Interpretations of the Soil Groups (Cont'd)

Soil Groups	Acres	Land Capability Class and Subclass	Soil Limitations for Cropland		Major Land Uses
			Without Irrigation	With Irrigation	
Hydric Lithic Dystrandepts					
Thixotropic, isomesic family	13,200	VIIs	Severe Extremely stony; bedrock 10 to 20 inches	Severe Extremely stony; bedrock 10 to 20 inches	Pasture Woodland Wildlife
Medial, isothermic family	3,900	IVs	Severe Bedrock 10 to 20 inches	Severe Bedrock 10 to 20 inches	Truck crops Orchards & vineyards Pasture Woodland, Wildlife
Lithic Dystrandepts					
Medial, isothermic family	8,000	VIs	Severe Very rocky; Bedrock 10 to 20 inches	Severe Very rocky; Bedrock 10 to 20 inches	Pasture Woodland Wildlife
EUTRANDEPTS					
Typic Eutrandepts					
Medial over fragmental, isohyperthermic family	3,300	VIIs	Severe Extremely stony; Low moisture	Severe Extremely stony	Orchards & vineyards Pasture Woodland Wildlife
Medial, isohyperthermic family	4,900	VIs	Severe Very rocky; Low moisture	Severe Very rocky	Sugarcane Pasture Wildlife
Medial, isothermic family	57,000	IIIe	Severe Low moisture	Slight	Truck crops Pasture Wildlife
Entic Eutrandepts	6,600	VIe	Severe Low moisture	Slight	Pasture Wildlife
Medial, isohyperthermic family					

Table 2.3. Agricultural Interpreations of the Soil Groups (Cont'd)

Soil Groups	Acres	Land Capability Class and Subclass	Soil Limitations for Cropland		Major Land Uses
			Without Irrigation	With Irrigation	
Ustollic Eutrandepts					
Medial, over fragmental isohyperthermic family	4,700	VIIs	Severe Extremely stony; Low moisture	Severe Extremely stony	Pasture Wildlife
Medial, isothermic family	16,900	IVe	Severe Low moisture	Slight	Pasture Wildlife
Medial, over fragmental isothermic family	41,900	VIIs	Severe Extremely stony; Low moisture	Severe Extremely stony	Pasture Wildlife
Lithic Eutrandepts					
Medial, isohyperthermic family	5,200	VIIs	Severe Extremely stony; Low moisture	Severe Extremely stony	Sugarcane Orchards & vineyards Pasture Woodland, Wildlife
HYDRANDEPTS					
Typic Hydrandepts					
Thixotropic, over fragmental, isohyperthermic family	8,600	VIIs	Severe Extremely stony	Severe Extremely stony	Sugarcane Orchards & vineyards Pasture Woodland, Wildlife
Thixotropic, isohyperthermic family	14,200	IIIe	Slight	Slight	Sugarcane
Thixotropic, isomesic family	145,300	IVe	Severe Soil temperature	Severe Soil temperature	Pasture Woodland Wildlife
Thixotropic, isothermic family	83,500	IVe	Moderate Slopes	Moderate Slopes	Sugarcane, Pasture Truck crops Orchards & vineyards Woodland Wildlife

Table 2.3. Agricultural Interpretations of the Soil Groups (Cont'd)

Soil Groups	Acres	Land Capability Class and Subclass	Soil Limitations for Cropland		Major Land Uses
			Without Irrigation	With Irrigation	
Medial, over thixotropic, isomesic family	6,200	IIIe	Slight	Slight	Truck crops Orchards & vineyards Pasture Woodland, Wildlife
Lithic Hydrandepts					
Thixotropic, isothermic family	7,500	IVs	Severe Bedrock < 20 inches	Severe Bedrock < 20 inches	Sugarcane Pasture Woodland, Wildlife
Thixotropic, isohyperthermic family	3,700	VIs	Severe Bedrock 10 to 20 inches	Severe Bedrock 10 to 20 inches	Sugarcane Truck crops Pasture Woodland, Wildlife
VITRANDEPTS					
Typic Vitrandepts					
Medial, over cindery isomesic family	30,200	VIIs	Severe Extremely stony; low moisture; soil temperature	Severe Extremely stony; soil temperature	Pasture Wildlife
Mollic Vitrandepts					
Medial, isothermic family	2,700	IVe	Severe Low moisture	Moderate Somewhat excessively drained	Pasture Woodland Wildlife
Medial, isomesic family	18,000	VIe	Severe Low moisture; soil temperature	Severe Soil temperature	Pasture Woodland Wildlife
Typic Vitrandepts					
Medial, isomesic family	35,700	VIe	Severe Low moisture; soil temperature; very stony	Severe Soil temperature; very stony	Pasture Woodland Wildlife

Table 2.3. Agricultural Interpretations of the Soil Groups (Cont'd)

Soil Groups	Acres	Land Capability Class and Subclass	Soil Limitations for Cropland		Major Land Uses
			Without Irrigation	With Irrigation	
PLACANDEPTS Typic Placandepts Thixotropic, isomesic family	10,000	VIw	Moderate Somewhat poorly drained, slopes	Moderate Somewhat poorly drained, slopes	Pasture Woodland Wildlife
ANDAQUEPTS Aeric Andaquepts Thixotropic acid, isothermic family	3,300	IVw	Moderate Somewhat poorly drained, slopes	Moderate Somewhat poorly drained, slopes	Sugarcane Pasture Woodland Wildlife
PLACAQUEPTS Histic Placaquepts Fine, mixed, acid, isomesic, ortstein family	12,200	VIIw	Severe Poorly drained; soil temperature	Severe Poorly drained; soil temperature	Wildlife
HUMITROPEPTS Andic Ustic Humitropepts Fine, oxidic, isothermic family	8,000	IIIe	Moderate Bedrock, 20 to 40 inches; high moisture	Moderate Bedrock, 20 to 40 inches	Sugarcane Truck Crops Orchards & vineyards Pasture Woodland, Wildlife
Ustic Humitropepts Very-fine, kaolinitic, isohyperthermic family	10,000	IIIe	Severe High moisture	Slight	Sugarcane Truck crops Orchards & vineyards Pasture Woodland, wildlife

Table 2.3. Agricultural Interpretations of the Soil Groups (Cont'd)

Soil Groups	Acres	Land Capability Class and Subclass	Soil Limitations for Cropland		Major Land Uses
			Without Irrigation	With Irrigation	
USTROPEPTS Typic Ustropepts Fine, kaolinitic, isohyperthermic family	8,800	VIIs	Severe Extremely stony; low moisture	Severe Extremely stony	Orchards & vineyards Pasture Wildlife
CAMBORTHIDS Ustollic Camborthids Medial, isohyperthermic family	29,000	VIIs	Severe Extremely stony; low moisture	Severe Extremely stony	Pasture Wildlife
HAPLUSTOLLS Aridic Haplustolls Fine kaolinitic, isohyperthermic family	3,400	VIs	Severe Very stony; low moisture	Severe Very stony	Sugarcane Truck crops Orchards & vineyards Pasture Woodland, wildlife
TROPOFOLISTS Typic Tropofolists Euic, isohyperthermic family	41,400	VIs	Severe Extremely stony	Severe Extremely stony	Orchards & vineyards Pasture Woodland Wildlife
Dysic, isohyperthermic family	15,500	"	"	"	"
Euic, isothermic family	25,200	"	"	"	"
Dysic, isothermic family	63,600	"	"	"	"

Table 2.3. Agricultural Interpretations of the Soil Groups (Cont'd)

Soil Groups	Acres	Land Capability Class and Subclass	Soil Limitations for Cropland		Major Land Uses
			Without Irrigation	With Irrigation	
Euic, isomesic family	48,100	VIs	Severe Extremely stony	Severe Extremely stony	Pasture, Woodland, wildlife
Dysic, isomesic family	16,400	"	"	"	"
Lithic Tropofolists					
Euic, isohyperthermic family	27,100	VIs	Severe Extremely rocky	Severe Extremely rocky	Orchards & vineyards Pasture Wildlife
Dysic, isohyperthermic family	35,400	"	"	"	"
Euic, isothermic family	25,700	"	"	"	"
Dysic, isothermic family	87,500	"	"	"	"
Dysic, isomesic family	153,700	"	"	"	Pasture Wildlife
Miscellaneous Land Types	1,272,420	VIIIs	Severe Variable	Severe Variable	Variable

Hydrologic Classification - Hydrologic soil groups are used in water resources planning to estimate runoff from rainfall. Soil properties that influence the minimum rate of infiltration obtained for a bare soil after prolonged wetting are considered. These properties are: structure, texture, depth of water table, intake rate and permeability after prolonged wetting, and depth to very slowly permeable layer. The influence of ground cover on runoff is treated independently--not in hydrologic soil groupings. Figure 2.4 shows the hydrologic grouping of the island's soils, while the following paragraphs define the groups shown.

Group A (Low runoff potential) - Soils having high to very high infiltration rates when thoroughly wetted. This group consists of (1) deep, well to excessively drained sands and silty clay loams, (2) cinders, (3) fragmental aa lava flows, (4) shallow organic soils over fragmental aa lava, and (5) soils having a combination of depth, apparent texture, aggregate stability, structure, and porosity that allows rapid water transmission.

Group B - Soils having moderate infiltration rates when thoroughly wetted. This group consists mainly of (1) mineral soils with kaolinitic clay, and (2) ashy soils that have a combination of depth, apparent texture, structure, aggregate stability, and porosity that allows moderate water transmission.

Group C - Soils having slow infiltration rates when thoroughly wetted. This group consists mainly of (1) soils with a layer that impedes downward movement of water, (2) soils with moderate water tables, and (3) clay soils that have a moderate shrink-swell potential that allows slow water transmission.

Group D (High Runoff Potential) - Soils having very slow infiltration rates when thoroughly wetted. This group consists of (1) very shallow soils over bedrock, (2) very steep shallow soils over saprolite, and (3) soils that have a high or very high shrink-swell potential. These soils have a very slow rate of water transmission.

All of the island's soils have been classified into these four groups. However, miscellaneous land types are not given a hydrologic group designation due to the extremely variable soil characteristics.

Vegetation Types

The vegetal delineations used on the Vegetation Type Map (Figure 2.5) were developed from Forest Type Maps prepared jointly by the Pacific Southwest Forest and Range Experiment Station of the U.S. Forest Service and the Hawaii Division of Forestry. Cultivated lands were delineated from aerial photos by the river basin survey staff. The vegetation types are described below and their distribution is shown in Table 2.4.

FIGURE 2.4

NORTH HALF

HYDROLOGIC SOIL GROUPS

HAWAII COUNTY

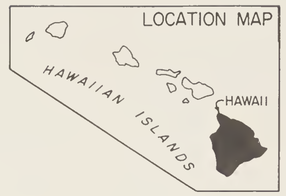
ISLAND OF HAWAII, HAWAII

SEPTEMBER 1973

5 0 5 10 MILES

SCALE 1:400,000

LOCATION MAP



SOIL CONSERVATION SERVICE · U.S. DEPARTMENT OF AGRICULTURE

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

Hydrologic Soil Groups

A — Soils having high infiltration rates when thoroughly wetted consisting chiefly of (1) deep, well to excessively drained sands and silty clay loams, (2) cinders, (3) fragmental aa lava flows, and (4) shallow organic soils over fragmental aa lava. These soils have a high rate of water transmission (more than 1.0 inch per hour) and a low runoff potential.

B — Soils having moderate infiltration rates when thoroughly wetted, consisting chiefly of (1) mineral soils with kaolinitic clay, and (2) oshy soils. These soils have a moderate rate of water transmission (0.5-1.0 inches per hour).

C — Soils having slow infiltration rates when thoroughly wetted consisting chiefly of (1) soils with a layer that impedes downward movement of water, (2) soils with a moderate water table, and (3) clay soils with moderate shrink-swell potential. These soils have a slow rate of water transmission (0.2-0.5 inches per hour).

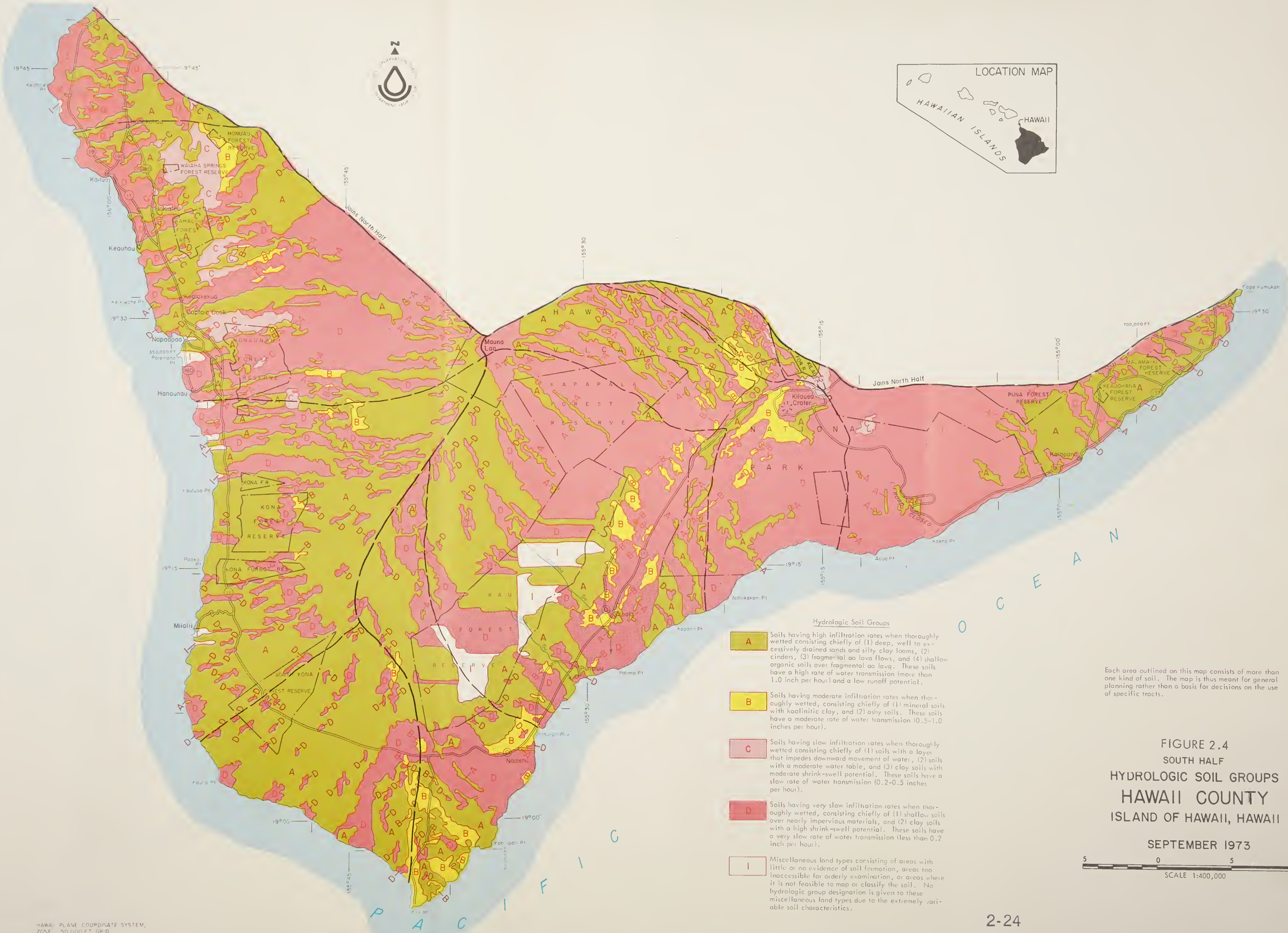
D — Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of (1) shallow soils over nearly impervious materials, and (2) clay soils with a high shrink-swell potential. These soils have a very slow rate of water transmission (less than 0.2 inch per hour).

I — Miscellaneous land types consisting of areas with little or no evidence of soil formation, areas too inaccessible for orderly examination, or areas where it is not feasible to map or classify the soil. No hydrologic group designation is given to these miscellaneous land types due to the extremely variable soil characteristics.

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS PORTLAND, OREG. 1973

North Half
M7-E-22697C-N



Hydrologic Soil Groups

A Soils having high infiltration rates when thoroughly wetted consisting chiefly of (1) deep, well to excessively drained sands and silty clay loams, (2) cinders, (3) fragmental aa lava flows, and (4) shallow organic soils over fragmental aa lava. These soils have a high rate of water transmission (more than 1.0 inch per hour) and a low runoff potential.

B Soils having moderate infiltration rates when thoroughly wetted, consisting chiefly of (1) mineral soils with kaolinitic clay, and (2) ashy soils. These soils have a moderate rate of water transmission (0.5-1.0 inches per hour).

C Soils having slow infiltration rates when thoroughly wetted consisting chiefly of (1) soils with a layer that impedes downward movement of water, (2) soils with a moderate water table, and (3) clay soils with moderate shrink-swell potential. These soils have a slow rate of water transmission (0.2-0.5 inches per hour).

D Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of (1) shallow soils over nearly impervious materials, and (2) clay soils with a high shrink-swell potential. These soils have a very slow rate of water transmission (less than 0.2 inch per hour).

I Miscellaneous land types consisting of areas with little or no evidence of soil formation, areas too inaccessible for orderly examination, or areas where it is not feasible to map or classify the soil. No hydrologic group designation is given to these miscellaneous land types due to the extremely variable soil characteristics.

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

FIGURE 2.4
SOUTH HALF
HYDROLOGIC SOIL GROUPS
HAWAII COUNTY
ISLAND OF HAWAII, HAWAII
SEPTEMBER 1973

5 0 5 10 MILES
SCALE 1:400,000

HAWAII PLANE COORDINATE SYSTEM,
ZONE 1, 50,000 FT GRID

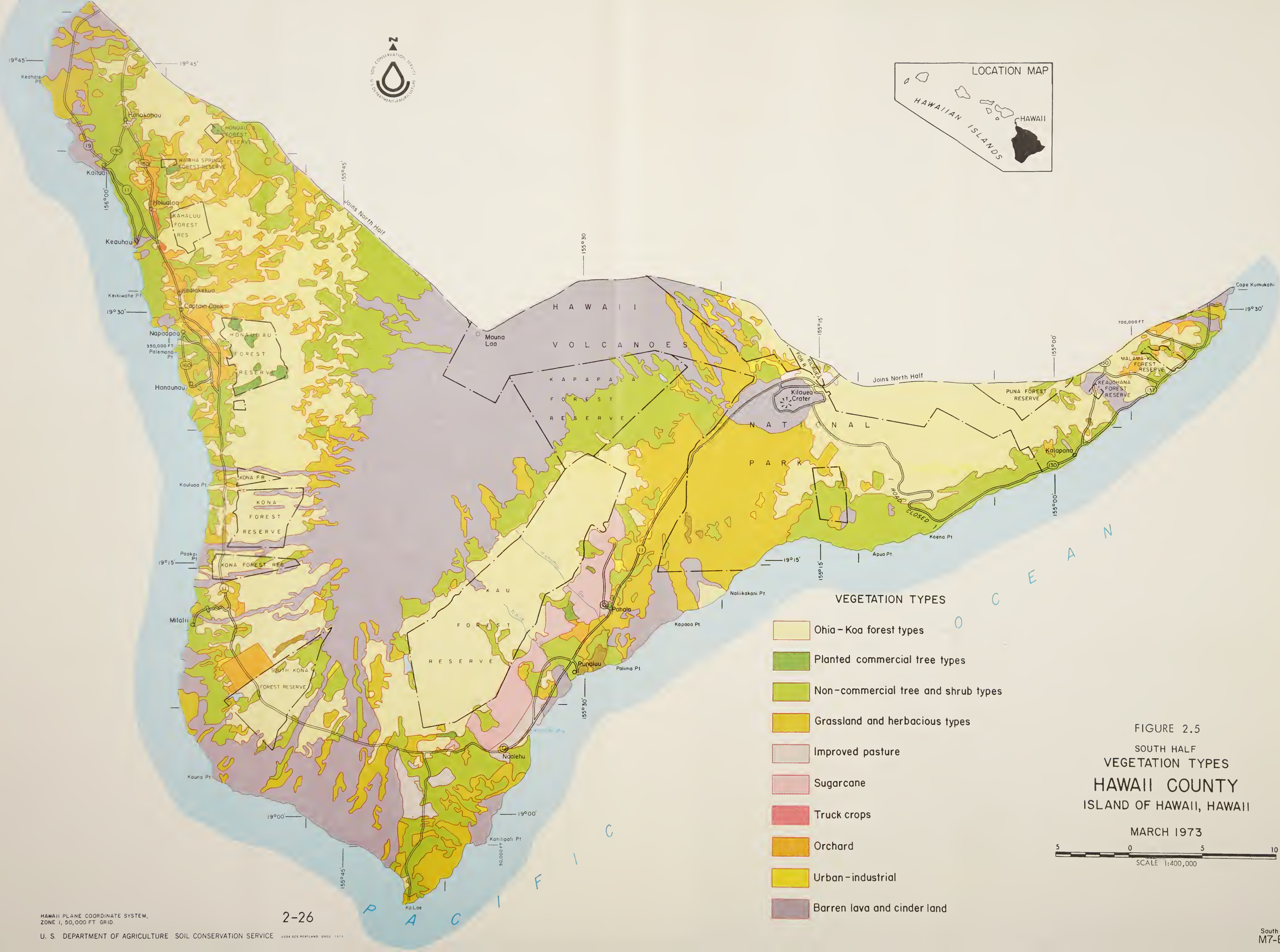
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

South Half
M7-E-22697C-N

HAWAII PLANE COORDINATE SYSTEM,
ZONE 1, 50,000 FT GRID.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OREG 1973

North Half
M7-E-22697D-N



VEGETATION TYPES

- Ohia-Koa forest types
- Planted commercial tree types
- Non-commercial tree and shrub types
- Grassland and herbacious types
- Improved pasture
- Sugarcane
- Truck crops
- Orchard
- Urban-industrial
- Barren lava and cinder land

FIGURE 2.5

SOUTH HALF

VEGETATION TYPES

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

MARCH 1973

5 0 5 10 MILES

SCALE 1:400,000

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS PORTLAND OREG. 1973

South Half
M7-EN-22697D

Table 2.4. Distribution of Present Vegetal Cover by Broad Types.

Vegetation Type	Area (in thousands of acres)	Percent to Total Island Area
Commercial, Native, and Naturalized	551.3	21.3
Planted Commercial Forest Types	15.9	0.6
Noncommercial Tree and Shrub Types	585.3	22.7
Nonforest Land (Including Agriculture, Urban, and Industrial)	1,431.7	55.4
Total	2,584.2	100.0

Commercial, Native, and Naturalized Forests - Ohia-koa Forest

This predominant native forest type occupies the higher rainfall areas of the island at elevations between 1,500 feet and 5,000 feet on the windward side, and between 1,000 feet and 3,500 feet in North and South Kona.

Ohia (Metrosideros polymorpha) is the principal species. A dense understory of treefern (Cibotium chamissoi) and various shrubs, vines, and herbs make these forests difficult to move through. Koa (Acacia koa) occurs sporadically in the lower portion of this zone. A mixture of ohia and koa is common in the transition area along higher elevations within the zone.

Koa trees are predominant in a narrow belt in the upper portion of the ohia-koa type. On the windward side of the island, the koa belt occupies an elevational zone from 4,000 to 7,000 feet, while along the South Kona coast, on the leeward side, the belt occurs at elevations from 3,500 to 4,500 feet. Cloud cover and fog commonly shroud this zone.

Formerly dense forest land, much of the koa type was overgrazed so heavily that the forest deteriorated. The remaining stands are generally open, with an understory of perennial grasses such as kikuyugrass (Pennisetum clandestinum), pangolagrass (Digitaria decumbens), sweet vernal (Anthoxanthum odoratum), and Hilograss (Paspalum conjugatum). The remaining trees are often decadent and koa reproduction and understory shrubs are scarce due to grazing.

Planted Commercial Forest Types

Commercial forest plantations on the island total more than 18,000 acres in stands from 2 acres to nearly 2,500 acres in size. About 7,500 acres of these plantations are sawtimber stands and some 10,500 acres are recently planted seedling, sapling, or poletimber stands.

Eucalypts are the principal tree species in older plantations, the most common species being Eucalyptus robusta. Other commercial hardwood species include saligna eucalyptus (E. saligna), silk-oak (Grevillea robusta), tropical ash (Fraxinus uhdei), and Australian red cedar (Toona ciliata var. australis). A lesser acreage of conifer plantations include Norfolk-Island-pine (Araucaria heterophylla), sugi (Cryptomeria japonica), and Monterey cypress (Cupressus macrocarpa).

Recent plantings have emphasized hardwoods other than eucalypts. Planted forests contain a smaller but significant part of the total timber volume. Yields per acre average much greater and the timber is of higher quality than native timber.

Non-commercial Tree and Shrub Types

This broad classification consists of lands which support scrub trees or brush but do not have soils and rainfall suited for growing timber crops. Greatly contrasting kinds of land are included in these sites. Some are too wet, as in the Waipio Valley, and some are too dry, as in the low leeward areas and on high mountain slopes. Soils have not yet formed on many recent and some older lava flows on the slopes of Mauna Loa, or are too thin to support timber growth. Tree- or brush-covered, rocky, precipitous slopes known as "pali" are also included in this type.

Some of the tree species included in this classification are kukui (Aleurites moluccana), ohia (Metrosideros polymorpha), koa (Acacia koa), and kiawe (Prosopis pallida). Koa haole (Leucaena glauca), guava (Psidium guajava), lantana (Lantana camara), and associated species comprise the lower elevation shrub type. Mamane (Sophora chrysophylla), pukiawe (Styphelia tameiameiae), 'A'ali'i (Dondonaea viscosa), and naio (Myoporum sandwicense) are the predominant species in the higher elevation shrub type.

Non-forest Land

Grassland and Herbaceous Type

Trees occupy less than 10 percent of the area and herbaceous vegetation (grass, herbs, and staghorn fern) is the predominant cover. At elevations below 1,000 feet where rainfall is less than 40 inches, piligrass (Heteropogon contortus), fingergrass (Chloris spp.), bristly foxtail (Setaria verticillata), bermudagrass (Cynodon dactylon), natal redtop (Tricholaena repens) and buffelgrass (Cenchrus ciliaris) predominate.

As the rainfall increases to 40 to 60 inches, bermudagrass and kikuyugrass (Pennisetum clandestinum) take over. At elevations above 2,500 feet, some of the temperate zone grasses, orchardgrass (Dactylis glomerata), brome (Bromus catharticus), and Kentucky bluegrass (Poa pratensis) are found.

In higher rainfall areas, 60 to 250 inches, the predominant grasses are hilograss (Paspalum conjugatum), sweet vernal (Anthoxanthum odoratum), yorkshire fog (Holcus lanatus), ricegrass (Paspalum orbiculare), and rattail (Sporobolus capensis).

At about 5,000 feet, as the rainfall starts to decrease with elevation, the grasses commonly found are hue pueo (Trisetum glomeratum), kalamaloa (Deschampsia nubiena), and mountain pili (Panicum tenuifolium).

Improved Pasture

All the major forage species are introduced. In the low rainfall areas below 1,000 feet elevation, the principal forage grasses are guineagrass (Panicum maximum) and buffelgrass (Cenchrus ciliaris).

Kikuyugrass and pangolagrass (Digitaria decumbens) are the principal species from 1,000 to 3,000 feet.

Orchardgrass, kikuyugrass, brome, Kentucky bluegrass, and tall fescue (Festuca elatior) predominate at 3,000 to 7,000 feet elevations.

Land Use and Management

The State Land Use Law of 1961 provided for establishment of four land use districts: conservation, agriculture, urban, and rural. The conservation district is administered by the State Department of Land and Natural Resources. The agency is responsible for subzoning and establishing and enforcing regulations to control the manner in which public and private lands within the district may be used. In the agriculture and rural districts, the Land Use Commission establishes the land use regulations and the counties administer them. The counties, however, may adopt more stringent controls than those imposed by the state within these two districts. Land use within the urban district is administered solely by the counties.

The distribution of land by districts is shown in Figure 2.6. The districts are briefly described below and are shown on the State Land Use District's Map (Figure 2.7).

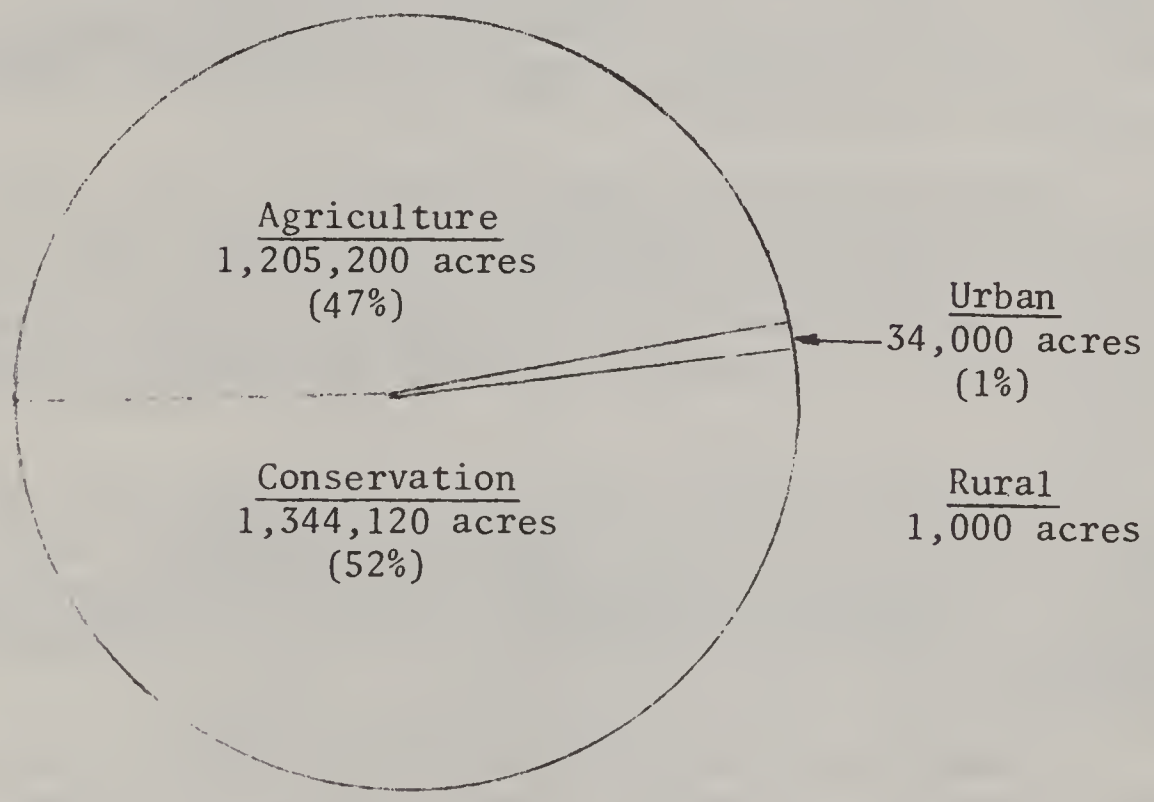


Figure 2.6. Distribution of State Land Use Districts, Island of Hawaii, 1969.

FIGURE 2.7

NORTH HALF

STATE LAND USE DISTRICTS

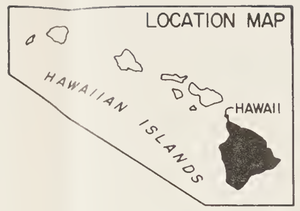
HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

MARCH 1973

5 0 5 10 MILES

SCALE 1:400,000



STATE LAND USE DISTRICTS

- Conservation
- Agricultural
- Urban
- Rural

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT. GRID

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1973

North Half
M7-E-22697E-N

South Half
M7-EN-22697E

Conservation districts include lands managed to protect watershed cover and water supplies; preserve scenic areas; provide for mountain, forest, and beach recreation areas; preserve example terrestrial and aquatic natural areas and flora and fauna; prevent floods and soil erosion; control use of nonrenewable natural resources; and promote effective perpetuation and use of renewable resources including timber, game, and other wildlife and forage.

The boundaries of the 700,000 acres of existing forest and watershed reserves provided the initial framework of reference for the delineation of conservation districts under the 1961 Land Use Law. The boundaries were extended, however, to include additional areas which were considered to be of primary importance for the above purposes. Hawaii Volcanoes National Park and the City of Refuge National Historical Park, as well as state and county parks, are also included in the conservation district. The district comprises a vast 1,344,120 acres, or 52 percent, of the island's total area.

Most state-owned lands within the conservation district are managed by the Forestry Division under the multiple-use concept which dictates that, in the absence of a demonstrable need for single or limited use of an area (for example, natural areas or watersheds of critical importance), skillful coordination of two or more uses will be the management goal. The objectives are to protect resources and to integrate different uses--watershed, timber production, recreation, wildlife, unique biota and ecosystems preservation, etc.--in the combination that will provide the greatest good for the greatest number of people in the long run.

While land use on the private lands within the conservation district is controlled by the state, it is the state's policy to encourage the appropriate development, utilization, and protection of these private lands, thus complementing the program on state-owned lands.

Agriculture districts include lands used for agricultural purposes and lands with a high capacity for intense cultivation. While 1,205,200 acres, or 47 percent of the island, are zoned agriculture, only 864,500 acres are presently in use.

Table 2.5 and Figure 2.8 show the major agricultural land uses on the island of Hawaii. The major sugarcane areas are in the Hamakua and Hilo subbasins along the Hamakua Coast from Hilo to Upolu Point. Truck crops are grown mostly in the Kohala, Hilo, and Kona subbasins. Coffee and macadamia nut orchards are also found in the Kona subbasin. The Ka'u subbasin includes a mix of grazing, orchard, and sugarcane. Finally, in the southern part of the Hilo subbasin, limited areas are used for grazing and sugarcane with macadamia nut and papaya orchards found near the coast.

Urban districts include lands in urban use plus sufficient reserve areas to accommodate foreseeable urban growth. The urban districts contain 34,000 acres, slightly more than 1 percent of the island's total area. In 1969, an estimated 13,300 acres of this urban zoned land was being used for residential, commercial, industrial, and resort purposes.

Table 2.5. Major Agricultural Land Uses - Island of Hawaii, 1967

Land Use	Acres	Percent of Island Area
Sugarcane	105,300	4
Truck Crops	1,200	-
Orchard	14,500	1
Grazing - Pasture	468,500	18
Grazing - Woodland	275,000	11
Total - Agricultural Use	864,500	34

Source: Statistics of Hawaiian Agriculture, 1968, U.S. Department of Agriculture, Statistical Reporting Service.

Grazing area from 1967 Conservation Needs Inventory

Rural districts include small farms and very low-density residential lots with a minimum lot size of one-half acre. Of the four districts, the rural district contains the least area, covering only 1,000 acres on the island.

Water Resources

The island of Hawaii receives an average of 75 inches of rainfall annually. Falling on a 4,030-square-mile area, this rainfall is equivalent to about 5,275 billion gallons. Depending upon the geographical location, this resource provides for streamflows, ground water recharge, and evapotranspiration in varying proportions. Figure 2.9 shows rainfall amounts and how they are distributed into the three broad occurrences for each hydrographic area of the island.

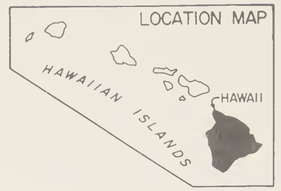
Perennial streams, with flows reaching the ocean, occur only in hydrographic areas I and II. Specifically, these are located along the Hamakua Coast between Hilo and Maulua River near Laupahoehoe, and in north Kohala between Waipio and Pololu. In these areas, rainfall is high and well distributed through the year to produce runoff from the highly permeable soils of the island. Boggy areas that detain some of the excess rainfall have developed. The delayed runoff from these areas, together with springflows at lower elevations, maintains the flows of the streams. Monthly distribution of annual runoff for these two hydrographics is shown in Figure 2.10.

FIGURE 2.8
NORTH HALF
GENERAL LAND USE
HAWAII COUNTY
ISLAND OF HAWAII, HAWAII

SEPTEMBER 1973

5 0 5 10 MILES
SCALE 1:400,000

LOCATION MAP



GENERAL LAND USE

- Urban
- Grazing
- Forest
- Sugar Cane
- Diversified Ag.
- National Park
- Conservation

U.S. SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

HAWAII PLANE COORDINATE SYSTEM,
ZONE 1, 50,000 FT GRID

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OREG 1973

North Half
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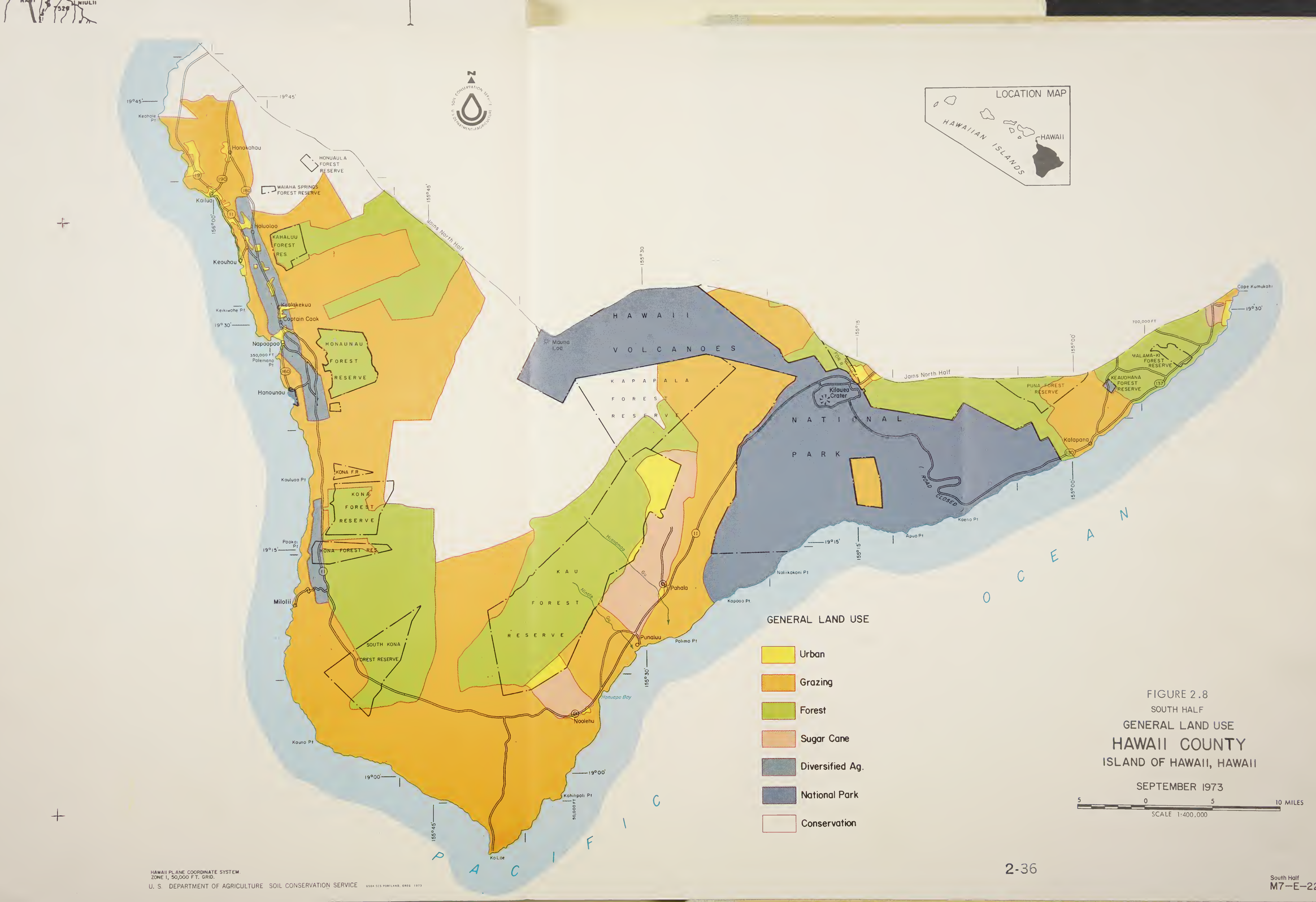
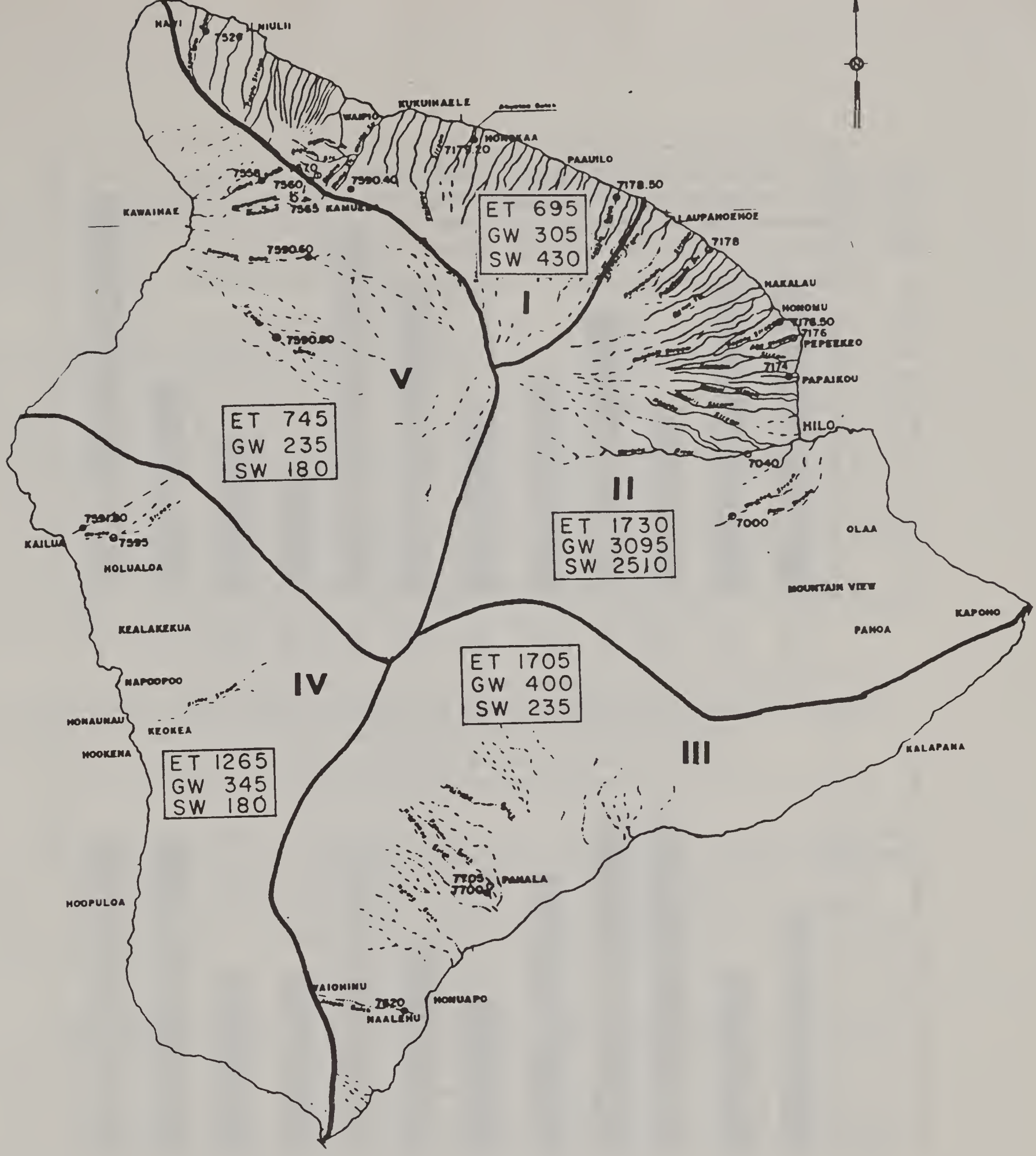


South Half
M7-E-22697F-N



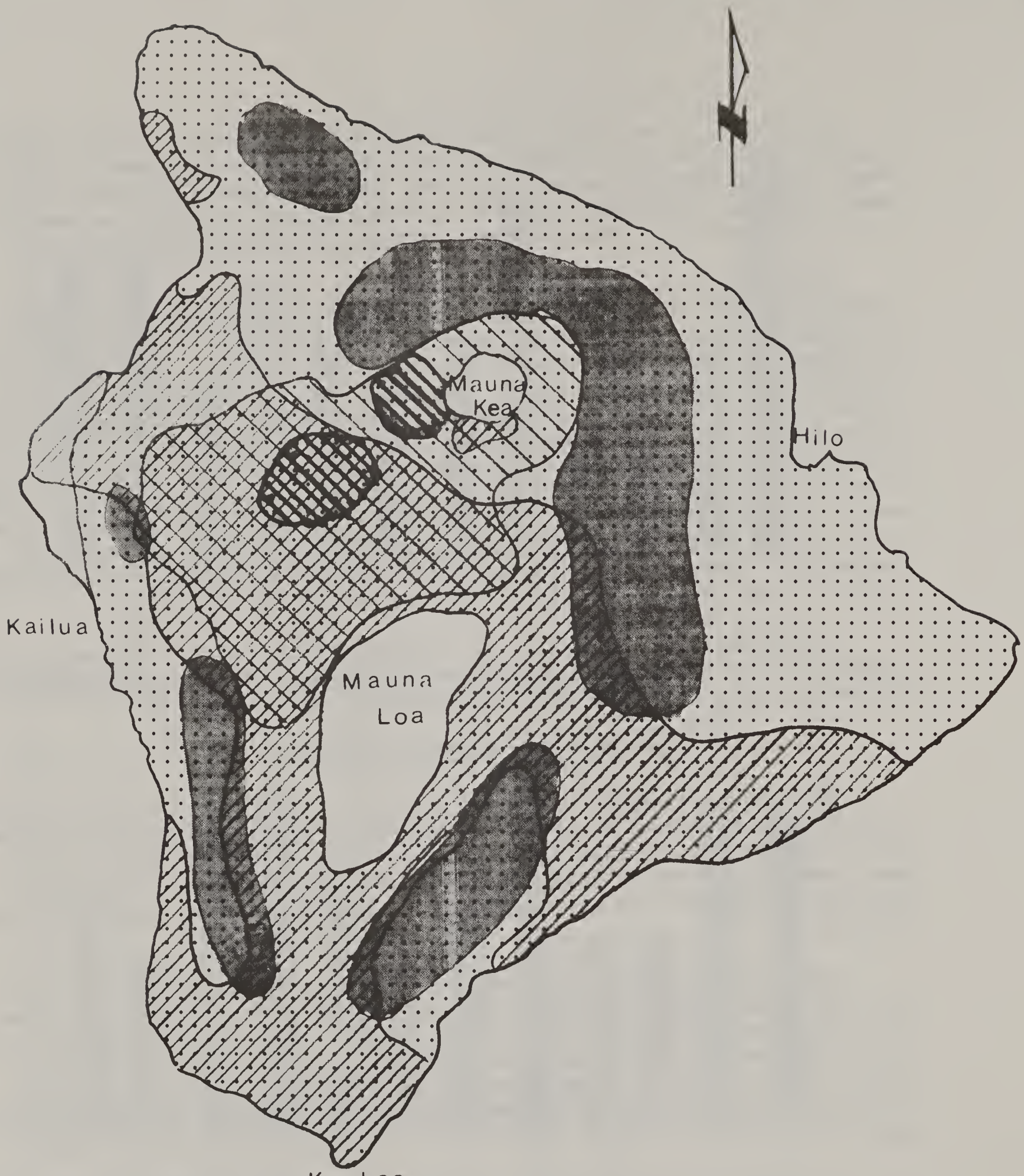
LEGEND

- ▬ – Hydrographic area
- ET – Evapotranspiration (MGD)
- GW – Recharge to ground water (MGD)
- SW – Discharge to surface water (MGD)
- o – Gaging Station
- ● – Crest-stage Station

Source: Hawaii Water Resources Regional Study Unpublished Information

4 0 4 8 MILES

FIGURE 2.9
DISPOSITION OF RAINFALL
BY HYDROGRAPHIC AREAS
HAWAII COUNTY
ISLAND OF HAWAII, HAWAII
MARCH 1975



LEGEND

- Feral Goat Range
- Feral Sheep Range
- Feral Pig Range
- Primary Feral Sheep Range
- Primary Feral Pig Range

No Primary Feral Goat Range Shown

FIGURE 2.11

RANGE OF FERAL GOATS, SHEEP, AND PIGS

HAWAII COUNTY
ISLAND OF HAWAII, HAWAII

Source: "Environmental Assessment - Impact of the Hawaii Statewide Pittmen-Robertson Program 1974-75 on Endangered Species of Wildlife and Their Habitats," 1974.

10 0 10 20
SCALE IN MILES

The many species of game birds which have been introduced provide sport for hundreds of hunters annually. The more successful introductions include ring-necked pheasant, Japanese blue pheasant, California valley quail, Gambel's quail, chukar partridge, Rio Grande turkey, lace-necked dove, barred dove, grey francolin, and black francolin.

Although they are found from sea level to 10,000 feet elevation, game birds generally prefer the grasslands and open forest types of the intermediate elevations. Only the dense rain forests, barren lava lands, and cane fields are unfavorable habitat for game birds.

Game fish inhabiting coastal and offshore waters provide the primary recreational and commercial fishing opportunities. The Kohala Public Fishing Area near Hawi is the only true freshwater fishery. The five reservoirs in the area total 60 acres and contain large and smallmouth black bass, bluegill sunfish, catfish, and carp. The Waiakea Public Fishing Area in Hilo, a 26-acre, spring-fed estuarine pond owned by the state, offers various brackish and saltwater species.

State Division of Fish and Game limnological surveys have identified over 30 streams (approximately 135 miles) with good potential for future development as public fishing areas. All of these perennial streams are located along the windward Hamakua Coast and appear well-suited for stocking with rainbow trout and/or smallmouth bass.

Nongame wildlife protected by state law includes the native land and sea birds, and the Hawaiian hoary bat--the island's only endemic mammal. Migratory birds are also protected in Hawaii by state and federal law.

All of the native land birds and some of the sea birds have suffered greatly from changes made in their environment by man. Of the 22 different nonmigratory native birds known to exist on Hawaii today, 11 are very rare or are considered to be in danger of becoming extinct. Twelve kinds of birds native to the island of Hawaii have not been seen by scientists in many years and are presumed to be extinct. Various factors are responsible for the decline and disappearance of these birds. Ground nesting species such as the shearwaters, dark-rumped petrel, rails, koloa (Hawaiian duck), and nene (Hawaiian goose) have all suffered severely from predation by introduced rats, mongooses, feral dogs and cats, and pigs. The reasons for the decline and elimination of the native forest dwelling birds are generally attributed to: loss of habitat through destruction of forest ecosystems by domestic and feral animals, avian disease from introduced birds to which native birds had very little resistance, and competition for food and space by introduced species of forest dwelling birds. Several species, including some now considered extinct, were caught in great numbers to provide feathers for the capes and helmets of Hawaiian royalty. The nene and koloa were shot for sport and food until early in this century, and the hawk, owl, and crow have also been reduced to dangerously low levels.

Fewer than 100 endemic waterbirds, including the stilt, coot, koloa, and night heron, remain in the suitable wetland areas, such as Opaeula and Honokahau ponds on the Kona Coast.

The living endemic forest dwelling birds on the island include the io (Hawaiian hawk), pueo (Hawaiian owl), alala (Hawaiian crow), uau (dark-rumped petrel), 'i'iwe, akepa, palila, akiapolaau, apapane, elepaio, amakihi, omao, ou, and creeper. Although populations of most of these species remain at dangerously low levels, no land birds are known to have become extinct since 1935, and in recent years several supposedly extinct species have been rediscovered. Since the early 1900's, protection of favorable native habitat has been aided by the establishment of forest reserves. The management or exclusion of feral and domestic animals from these lands would further benefit the endangered wildlife. More recently, known critical habitats have been set aside as wildlife refuges and sanctuaries, and procedures have been implemented to regulate future exotic bird and mammal introductions. Through a careful and costly propagation and release program initiated in 1948, the island's nene population has been increased from less than 50 birds to about 600. A similar program for restoration of koloa is also underway.

Due to the limited suitable habitat for waterbirds, about a hundred migratory waterfowl, mainly pintail and shoveller ducks, wintered on the island in 1969. Other migratory birds, ranging the upland areas as well as the seashore, include the golden plover, ruddy turnstone, and wandering tattler.

Quality of the Environment

Natural Features

The island has a variety of climate, terrain, and scenic attractions. Desert and rainforest, beaches and snowy peaks, steaming volcanoes and green valleys all exist on Hawaii. Up high, the volcano lands resemble the moon's surface and pose a harsh, hostile environment. But at lower levels, diverse agricultural activities flourish in a temperate climate. The striking contrasts and the island's rural character provide an attractive environment for recreation, working, and living.

Along the Hamakua coast, sea cliffs tower above the Pacific. Hamakua is sugar country and green cane dominates its landscape. Above the cane lie misty forests and pastures dotted with eucalyptus. Numerous streams fed by a year-round abundance of rain have cut deep valleys into the coastal bluff.

Kohala, the Big Island's northwest corner, includes: the windswept Waimea plateau with cattle ranches and truck farms; the sun-baked Kawaihae coast; and the Kohala Mountains whose grasslands roll up the forested hills, flatten out into cane land on the north, and break apart on the northeast into green canyons.

The sunny Kona coast houses one of the state's major resort areas in and around the village of Kailua. However, Kona is cool and green on the western slopes of Mauna Loa and Hualalai. Coffee and macadamia nut orchards, native forests, and rolling pastures provide a pleasant backdrop to the rocky coastline.

Ka'u, the southern section of the Big Island, includes: South Point (Ka Lae), a rugged cape with green olivine sand beaches; mixed grasslands and uniform blocks of macadamia nut orchards running up Mauna Loa's slopes through the country's highest (3,300 feet) cane fields; the Ka'u desert on Kilauea's southwest slope; and the Hawaii Volcanoes National Park with its smoking, bubbling phenomena.

Puna, the southeastern part of the island, exhibits contrasts of rural tranquility and violent upheaval. Black sand beaches and the blackened remains of lava flows give evidence of Kilauea's violence while fields of orchids, anthuriums, and papayas, macadamia nuts, tropical rainforests, and rolling cane fields enhance the area's rural nature.

Destructive Factors

Destructive factors that have damaged or depleted the island's natural resources and pose a future threat include: wildfire, overgrazing, clearing and later abandonment of agricultural lands, substandard subdivisions, insects, disease, aggressive plant pests, and lava flows.

III. ECONOMIC DEVELOPMENT

The purpose of this chapter is to provide an economic framework for estimating future needs for water and related land resources development on the island of Hawaii and for appraising alternative water and land development potentials and opportunities for meeting these needs. A national framework of economic projections is presented in the appendix. Recent growth in the state and on the island of Hawaii is analyzed. Present economic and agricultural conditions are described. Selected projections for the state and island are presented.

Historical Development

At the time of its discovery by Captain Cook in 1779, the island of Hawaii was divided into several polynesian kingdoms, each organized as a feudal type of society. Taro cultivation and fishing were the major economic activities supplemented by other crops, principally sweet potatoes, yams, breadfruit, sugarcane, and coconuts. Raising of pigs, dogs, and chickens constituted the significant livestock enterprises. The foundation of the present economy was laid between 1815 and 1835 with the establishment of cattle raising and the organization of the first sugar plantation. The growth of agriculture stimulated immigration from the U.S. mainland, from the Far East, and later from the Philippines and Europe, giving the island its present harmonious multiracial society.

General Description of the Economy

Land Use, Urban Centers, and Transportation

The island of Hawaii is mostly rural. Approximately 54 percent of the land area is in farms, but only 8 percent of the land in farms is devoted to harvested crops. Forest, pasture, and barren lava lands cover most of the island. Federal lands, consisting chiefly of national parks, occupy 8 percent of the island.

The city of Hilo, with a population of 26,353 in 1970, is the major urban center. The U.S. Census of Population lists 21 other places with populations ranging from 200 to 1,900. Most of these smaller towns are homes of sugar plantation employees and local trading centers. The rapidly growing tourist industry is centered in the city of Kailua in the North Kona District. Persons employed by the tourist industry, as well as local service centers for diversified crop and livestock production, reside in the population centers in the North Kona, South Kona, and South Kohala Districts.

As of 1968 the island was served by 428 miles of state highways, 849 miles of county roads, and 77 miles of national park roads. Two deep water harbors at Hilo and Kawaihae handle agricultural exports and receive consumer goods. Commercial passenger traffic is funnelled through airports at Hilo, Ke-ahole, and Waimea.

Population

Population trends since the turn of the century have been related to employment opportunities (Table 3.1). During the first six decades of the century the trend was typical of most agricultural counties with a peak between 1930 and 1940 and a substantial decline until 1960 due to mechanization and lessened manpower requirements in agriculture. The halt in the decline of population in the 1960 decade primarily reflects the rapid development of the tourist industry and, to a lesser extent, the establishment of homes by retired persons.

Table 3.1. Total Resident Population, Island of Hawaii and State of Hawaii, Actual 1900-1970 and Projected 1980

Year	Island of Hawaii	State of Hawaii
	1,000	
1900	46.8	154.0
1920	64.9	255.9
1940	73.3	422.8
1960	61.3	632.8
1970	63.5	769.9
1980	87.0	863.5

1900-1960: State of Hawaii General Revision Program, Part 4, Population Projections, State of Hawaii, Department of Planing and Economic Development, 1967, Table 4.

1970: U.S. Bureau of Census, Preliminary, as reported in Statistical Report 79, Hawaii State Department of Planning and Economic Development, Jan. 8, 1971.

In the decade from 1960 to 1970 the combined effects of lessened labor requirements in agriculture and new opportunities in tourism resulted in a small population increase of about 2,000 (Table 3.2). Population gains were concentrated in the South Hilo District, which houses the city of Hilo, and in the South Kohala and North Kona Districts. Moderate losses in population occurred in the North Hilo, Hamakua, and South Kona Districts. Future population growth is expected to occur primarily in the South Hilo, South Kohala, and North Kona Districts with lesser gains expected for the Hamakua, South Kona and Ka'u Districts. The stable population level projected for the North Kohala District assumes that alternative employment can be found for workers displaced by the closing of the Kohala Sugar Company in 1973.

Table 3.2. Total Resident Population by Judicial Districts, Hawaii County (Actual and Projected).

District	Year		
	1960	1970	1980
Puna	5,030	5,154	5,200
South Hilo	31,553	33,915	40,000
North Hilo	2,493	1,881	1,800
Hamakua	5,221	4,648	5,100
North Kohala	3,386	3,326	3,300
South Kohala	1,538	2,310	5,700
North Kona	4,451	4,832	16,200
South Kona	4,292	4,004	4,600
Ka'u	3,368	3,398	5,100
Total	61,332	63,468	87,000

Sources: 1960, 1970: State of Hawaii, Department of Planning and Economic Development, Statistical Report 79, January 8, 1971.

1980: Independently projected, based on (a) projected employment in tourist industry and continued moderate decline in agricultural employment, (b) unofficial projections by the Department of Planning, County of Hawaii, and (c) projections of population in Interim Revisions of Population Projections in the State General Plan, Memorandum from Shelly M. Mark, Director, Hawaii State Department of Planning and Economic Development, November 24, 1969. The projected population of 87,000 compares with a population of 84,000 projected by the Department of Economic Development of Hawaii County at the lowest of 3 alternative levels.

Land Tenure

The high concentration of landownership on the island is typical of the state (Table 3.3). Figure 3.1 shows the distribution of landownership on the island. Large landowners fall into two types: those who lease out land to others, and those who use their land themselves primarily for agricultural purposes. In 1964 some 626,000 acres on the island was under lease including 597,000 acres leased for agricultural purposes. The largest lessor of agricultural lands was the state of Hawaii with 284,500 acres leased out, followed by the Bishop Estate, which leased out 258,800 acres. In 1964 some 537,000 acres were leased for grazing, some 34,000 acres for sugarcane, and approximately 26,000 acres for diversified agriculture. Apparently, these magnitudes have not changed greatly since 1964.

Table 3.3 Pattern of Landownership, Hawaii County, 1964*

Type of Owner	Number	Acres Owned	Proportion of island land area	
			Percent	Cumulative Percent
Public				
State of Hawaii	1	1,126,200	43.8	43.8
Federal	1	211,000	8.2	52.0
Private (by acres owned)				
Over 100,000	4	726,200	28.2	80.2
10,000 - 100,000	13	257,100	9.9	90.1
1,000 - 10,000	21	69,200	2.7	92.8
Totals	40	2,389,700*	92.8	--

*Because of differences in sources, acreage figure differs somewhat from corresponding figure elsewhere in the report.

Source: Public Land Policy in Hawaii, Major Landowners, Legislative Reference Bureau, University of Hawaii, Report No. 3, 1967.

The 10 sugar plantations on the island in 1968 were owned by four companies with statewide agricultural and nonagricultural interests. The same concerns also owned two of the larger ranches with 1,000 or more heads of cattle.

Of 2,639 farms counted by the Census of Agriculture in 1964, 57 manager-operated farms occupied some 1.2 million acres or 87 percent of the land in farms. The remaining 2,582 farms were mostly family enterprises. Of these, 1,640 were operated completely or partly on land rented from large private landowners and the state of Hawaii.

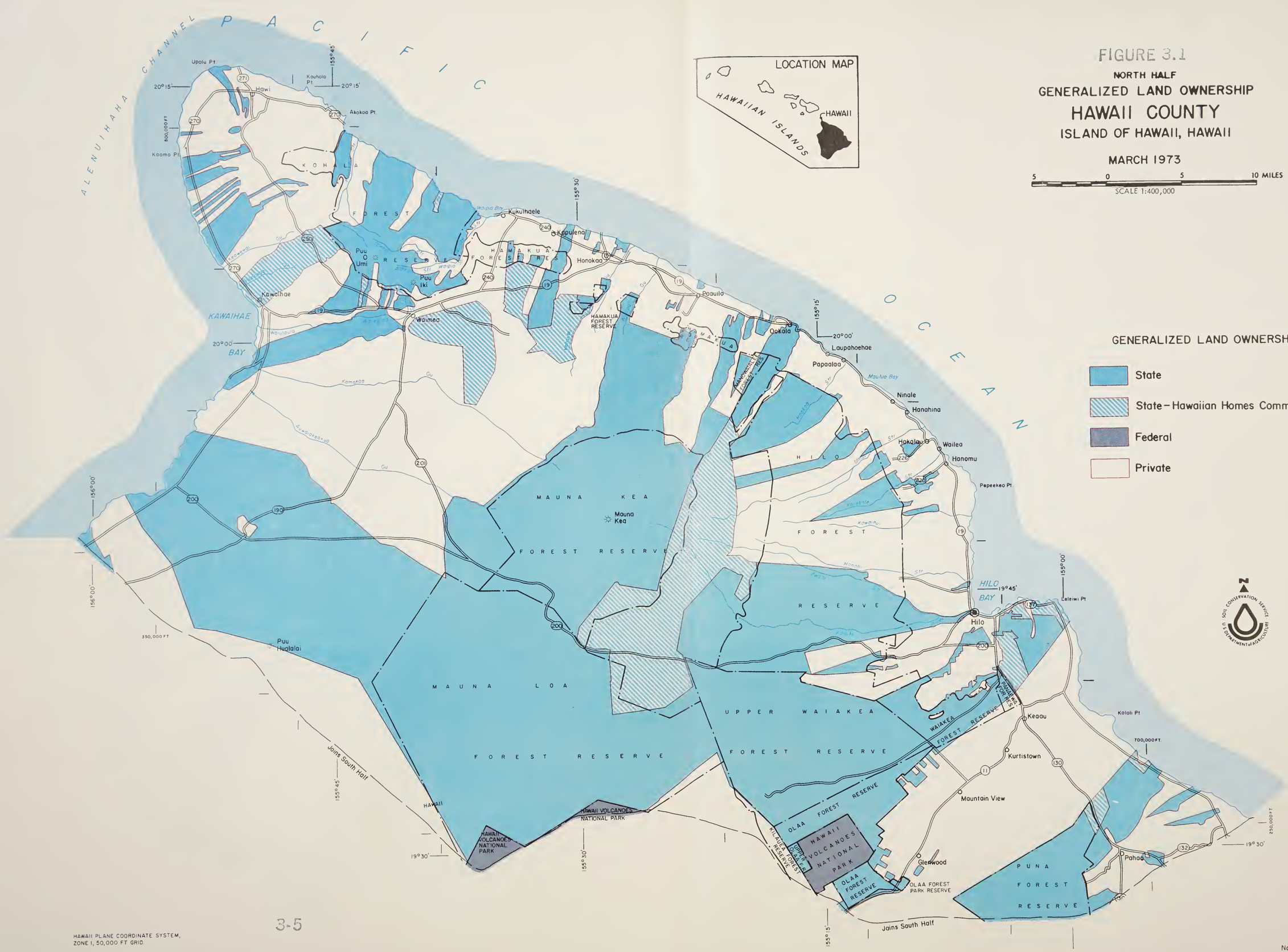


FIGURE 3.1

NORTH HALF

GENERALIZED LAND OWNERSHIP

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

MARCH 1973

5 0 5 10 MILES

SCALE 1:400,000

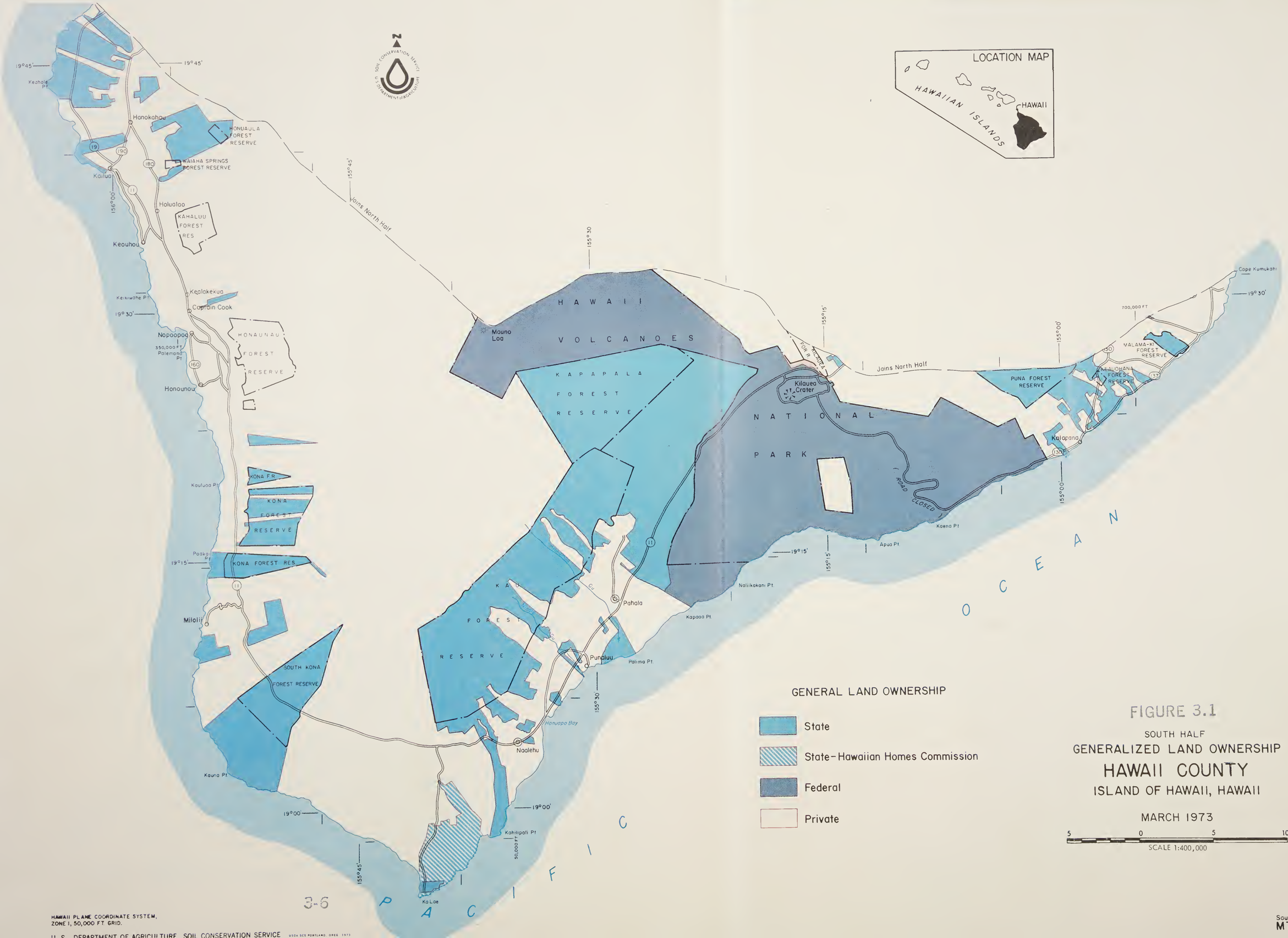
GENERALIZED LAND OWNERSHIP

- State
- State – Hawaiian Homes Commission
- Federal
- Private

HAWAII PLANE COORDINATE SYSTEM,
ZONE 1, 50,000 FT GRID.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OREG 1973

North Half
M7-E-22697G-N



GENERAL LAND OWNERSHIP

- State
- State-Hawaiian Homes Commission
- Federal
- Private

FIGURE 3.1

SOUTH HALF

GENERALIZED LAND OWNERSHIP

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

MARCH 1973

5 0 5 10 MILES

SCALE 1:400,000

HAWAII PLANE COORDINATE SYSTEM,
ZONE 1, 50,000 FT. GRID.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND, OREG. 1973

South Half
M7-E-22697G-N

The landownership pattern results in an agricultural labor force that consists of both unionized labor in the sugar industry and traditional family labor supplemented by hired workers. In 1968, 1,960 persons were employed by the sugar industry. During the same year, there were 2,110 self-employed and unpaid family workers and 930 paid workers in agricultural enterprises other than sugarcane.

Employment and Major Types of Economic Activity

The economic structure of Hawaii County and recent changes in employment are revealed by the distribution of the labor force in Table 3.4. The economy is based on three industries--agricultural production, agricultural processing, and tourism. The other economic activities are largely induced by these basic activities.

The value of agricultural production increased from $61.8 million in 1960 to $94.7 million in 1968. During the same period, employment in the hotel industry rose from 480 to 1,830 workers with tourist expenditures in Hawaii County estimated at $30.5 million for 1967.[1/] Thus, agriculture remains an important economic activity on the island. The value of agricultural production by major commodities is given in Table 3.5. Trends in volume (value) of agricultural production are given in Table 3.6.

The major activity in the food processing sector is extracting raw sugar from sugarcane. This process was carried on in 10 sugar plantation mills and employed some 1,900 workers in 1968. Other food processing activities consist of a meat processing plant, two macadamia nut plants, and a dairy plant. Smaller establishments process fruit juice, coffee, jams, and jellies. The taxable payrolls for manufacturing food and kindred products was $3.8 million for the first quarter of 1968, equivalent to an annual payroll of $15.2 million.

The island of Hawaii has a small commercial fishing industry which produced a catch of nearly 800,000 pounds worth $310,800 in the year ending July 1970. The industry has been declining in recent years and the catch of the year ending in July 1970 was less than half the catch in 1965.

Income

Per capita personal income in Hawaii County was $2,709 in 1967, $622 below the state level, and $450 below the national level. The lower income figures are due to relatively low returns to labor in diversified agriculture, the tourist industry and retail trade, offset in part by higher wages paid by the sugar industry.

Agricultural Base and Projections

Agricultural production on the island of Hawaii is geographically concentrated by major products and enterprises (Table 3.7). These, estimated by hydrologic areas, are based on 1964 census data by Minor Civil Divisions (MCD). While hydrologic and MCD boundaries do not coincide, the similarity seems sufficient to point up the location thesis.

1/ Economic Research Associates, Hawaii Land Study, Table 33.

Table 3.4. Distribution of the Labor Force, Hawaii County, 1960 and 1968.

Sector	Year	
	1968	1960
	Number	Number
Agriculture	5,000	5,800
Food Processing	2,370	2,640
Hotels	1,830	480
Other Manufacturing	560	660
Other Services & Miscellaneous	1,750	1,160
Wholesale & Retail Trade	4,340	3,100
Government	4,000	3,050
Other Non-major	6,150	4,630
Unemployed	840	750
Total	26,840	22,270

Source: State of Hawaii Department of Labor and Industrial Relations, Bureau of Employment Security.

Table 3.5. Value of Agricultural Production, Island of Hawaii, 1968

Commodity	Value
	1,000 dollars
Sugar*	74,400
Cattle	7,825
Macadamia nuts (in shell	2,294
Vegetables and melons	2,113
Papayas	1,925
Coffee	1,545
Eggs	1,127
Flowers, foliage and nursery products	1,100
Milk	784
Hogs	508
Fruits (excluding papayas)	411
Broilers and chickens	183
Others	545
Total	94,760

* Comprises raw sugar valued at $67,500,000, molasses valued at $2,300,000 and government payments of $4,600,000.

Source: U.S. Dept. of Agriculture, Statistical Reporting Service, Statistics of Hawaiian Agriculture, 1968.

Table 3.6. Index of Volume of Production for Major Crop and Livestock Enterprises, Hawaii County, 1960-1968 (1960 = 100)

Product	Year								
	1960	1961	1962	1963	1964	1965	1966	1967	1968
Raw sugar	100	109	114	108	124	132	122	128	132
Cattle (dressed weight)	100	99	92	100	98	98	118	135	147
Macadamia nuts	100	147	205	239	303	341	352	321	409
Vegetables and melons	100	102	128	126	140	142	148	145	131
Papayas	100	137	148	162	305	234	241	294	308
Coffee	100	63	101	50	75	57	61	43	47
Eggs	100	99	118	130	131	127	114	116	114
Flowers, foliage & nursery products	100	100	100	100	106	106	119	125	138
Milk	100	98	106	119	120	135	159	170	146
Hogs (pork)	100	104	103	126	141	153	130	140	146
Fruits (excluding papayas)	100	138	148	154	76	127	213	175	179
Broilers and chickens	100	105	109	111	158	130	107	119	98

Source: U.S. Department of Agriculture, Statistical Reporting Service, Statistics of Hawaiian Agriculture, 1968.

Table 3.7. Number of Farms, Land Use, and Selected Crops and Livestock, Island of Hawaii, by Hydrologic Areas, 1964.

Land Use	Hydrologic Area					
	Kohala*	Hamakua*	Hilo	Ka'u	Kona	County
MCD	2	1-3-4	5-6-7-8	9-10	11-12	
	- - - - - - - - - - - - - Number - - - - - - - - - - - - -					
Farms	108	305	1,092	228	906	2,639
	- - - - - - - - - - - - - Acres - - - - - - - - - - - - -					
Land Area	-	-	-	-	-	2,573,440
Land in Farms	272,819	150,811	202,931	326,876	424,980	1,378,417
Cropland Harvested	877	18,409	24,874	9,473	6,362	59,995
Sugarcane	12	17,146	22,528	7,473	0	47,159
Coffee	5	37	60	81	4,525	4,708
Papayas	0	1	57	922	12	992
Macadamia Nuts	21	1,055	1,274	568	1,441	4,358
	- - - - - - - - - - - - - Dollars - - - - - - - - - - - - -					
Vegetables Sold	765,726	74,370	387,769	39,055	274,707	1,541,627
	- - - - - - - - - - - - - Number - - - - - - - - - - - - -					
Cattle & Calves	41,667	22,739	10,687	18,885	32,467	126,445
Milk Cows	117	324	264	351	93	1,139

* This area includes large portions (mostly grazing) of MCD 1, 4, and 11.

U.S. Census of Agriculture, 1964.

Most of the 2,639 farms in 1964 were in the Hilo and Kona subbasins. But the Hamakua and Hilo subbasins were substantially the largest in terms of cropland harvested.

Coffee production is concentrated in the Kona subbasin while Ka'u produced nearly all the papayas. All areas except Kohala produce large amounts of macadamia nuts. Vegetables are most important in the Kohala, Hilo, and Kona subbasins.

Cattle and calves are produced in all areas. But Ka'u, Kohala, and Kona with large areas of grazing land have the largest number of cattle.

Food Consumption

Consumption of major agricultural products, per capita and total in the state, are summarized in Table 3.8 for 1967 and projected 1980. Excluded from the analysis were certain products, principally poultry, dairy, hogs, flowers, and nursery products which have minor requirements for land and water development. The projected 1980 population of the state is 1.037 million including 892,700 civilian residents, some 91,600 tourist equivalents, and 52,300 members of the armed forces.

Production Projections

A summary of statewide and Hawaii County production of major crops and livestock produced on the island is shown in Table 3.9 for a base year 1967 and projected 1980.

The acreages and yields associated with production quantities, 1967 and 1980, are shown in Table 3.10 for Hawaii County. In most instances, yields per acre are projected to increase.

Fresh Vegetables

The analysis is centered on seven vegetables which accounted for 82 percent of the vegetable acreage in Hawaii County from 1960 to 1965, and for almost 90 percent since 1965. Per capita consumption of all vegetables is expected to remain relatively constant to 1980. With the increased population, significant changes in total consumption of most vegetables is expected. For lettuce, the increased per capita consumption and population growth is expected to more than double the total consumption, with most other crops rising by one-half.

Statewide production of vegetables is projected to continue to fall short of consumption with imports supplying most of the lettuce and tomatoes consumed in the state in 1980. Vegetables in Hawaii are produced in competition with the highly efficient operations on the West Coast and in the face of continually shrinking costs of transportation from the mainland.

Table 3.8. Consumption of Selected Major Agricultural Products Per Capita, Island of Hawaii and State of Hawaii, 1967 and 1980.

Product	Per Capita Consumption		Total Consumption	
	1967	1980	1967	1980*
			1,000	1,000
Fresh Vegetables	lbs.	lbs.	lbs.	lbs.
Chinese Cabbage	5.2	5.2	3,789	5,341
Celery	5.9	5.8	4,331	5,983
Cucumbers	5.7	5.5	4,158	5,704
Daikon	4.9	2.9	3,625	3,018
Head Cabbage	13.9	14.7	10,103	15,254
Lettuce	17.5	25.5	12,757	26,444
Tomatoes	12.9	12.8	9,371	13,274
Fruits				
Avocados**	1.7	1.0	1,213	1,037
Bananas**	11.1	13.0	8,117	13,481
Papayas	19.7	17.3	14,332	17,940
Macadamia Nuts (in shell)	9.7	13.3	7,129	13,787
Beef and Veal (dressed)	85.0	80.0	61,890	82,960

*Based on population of 1,036,605 including 892,700 resident civilians, 91,572 tourist equivalent and 52,333 members of armed forces.

**Varieties locally produced in 1967.

1967: U.S. Department of Agriculture, Statistical Reporting Service, Statistics of Hawaii Agriculture, 1968.

1980 Projections: Economic Base Study Element Report, Hawaii Water Resources Regional Study, Honolulu, Hawaii, 1975.

Table 3.9. Production of Selected Major Agricultural Products, Hawaii County and State of Hawaii, 1967 and 1980.

Product	State of Hawaii		Hawaii County			
	1967	1980	1967		1980	
	1,000 pounds	1,000 pounds	1,000 pounds	Percent of State	1,000 pounds	Percent of State
Vegetables						
Chinese Cabbage	3,740	6,251	2,760	74	6,251	100
Celery	2,200	0*	2,200	100	0*	0*
Cucumbers	4,100	4,291	1,700	41	3,291	77
Daikon	3,625	2,308	2,460	68	1,168	51
Head Cabbage	9,800	11,405	1,175	12	1,114	10
Lettuce	7,100	18,020	4,000	56	0	0
Tomatoes	6,200	2,534	3,210	52	0	0
Fruits						
Avocados**	1,205	723	1,005	83	723	100
Bananas	8,095	2,782	2,165	27	0	0
Papayas	22,845	44,477	19,093	84	28,057	63
Macadamia Nuts (in shell)	7,972	53,763	7,900	99	43,010	80
Sugar	1,191***	1,271***	440***	37	459***	36
Coffee (parchment)****	8,040	NA	8,040	100	NA	
Beef and Veal (dressed)	31,277	38,500	18,733	60	29,165	76

*Less than 25 acres harvested.
**Varieties locally produced in 1967.
***In 1,000 tons.
****Roasted coffee amounts to two-thirds of parchment.
1967: U.S. Department of Agriculture, Statistical Reporting Service, Statistics of Hawaiian Agriculture, 1968.
1980 Projections: Economic Base Study Element Report, Hawaii Water Resources Regional Study, Honolulu, Hawaii, 1975.

Table 3.10. Acres and Yields of Selected Major Crops, Hawaii County, 1967 and 1980

Crop	1967		1980	
	Acres	Yield	Acres	Yield
		1,000 pounds		1,000 pounds
Vegetables				
Chinese Cabbage	195	14.1	306	20.4
Celery	70	31.4	0	0.0
Cucumbers	55	30.9	109	30.0
Daikon	210	11.7	111	10.5
Head Cabbage	100	11.8	66	17.0
Lettuce	325	12.3	0	0
Tomatoes	90	35.7	0	0
Other Vegetable Crops	155		249	
Total Vegetables	1,200		849	
Fruits				
Avocados in Crop	380		380	
Avocados Harvested	150	6.7	93	7.8*
Bananas in Crop	340		0	
Bananas Harvested	300	7.2	0	0
Papayas	620	30.8	935	30.0
Other Fruit Crops	640		800	
Total Fruits	2,000		2,115	
Macadamia Nuts				
In Crop	7,920		12,826	
Harvested	3,280	2.4	10,322	4.17
Sugar		Tons		Tons
In Crop	105,300		97,577	
Harvested (raw sugar)	46,900	9.38	43,689	10.5
Coffee	4,600	1.24**	NA	

*Yield estimated for varieties bearing in 1967.
**Parchment.
1967: U.S. Department of Agriculture, Statistical Reporting Service, Statistics of Hawaiian Agriculture, 1968.
1980 Projections: Economic Base Study Element Report, Hawaii Water Resources Regional Study, Honolulu, Hawaii, 1975.

Hawaii County's share of statewide production of the seven vegetables is substantial and, with the exception of lettuce and tomatoes, generally rising (Table 3.9). The Waimea area will remain the largest producer followed by the Volcano and Kona areas. Production in other areas is expected to be minor.

Fruits

Avocados, bananas, and papayas have accounted for approximately two-thirds of Hawaii County's fruit acreage in recent years. Because of competition for other producing areas and production problems, banana and avocado acreage is expected to decline substantially. A more optimistic future for avocados is possible if experimental varieties planted in 1966-67 succeed in gaining consumer acceptance, or, if markets for frozen avocados can be developed.

The increase in papaya acreage will more than offset the expected decline in bananas, resulting in an increase in fruit acreage from 2,000 acres in 1967 to about 2,115 acres in 1980. Larger increases are possible if export restrictions on tropical fruits can be overcome and if the problem of replanting papayas can be solved.

In recent years, approximately 300 acres of wild growing guavas have beeen harvested in Hawaii County. Guava expansion is possible if expanded processing can be developed.

Macadamia Nuts

Research completed at the University of Hawaii indicates a demand for macadamia nuts in 1980 of 25 million pounds shelled, of which 20 million pounds are mainland demand and 5 million pounds demand within the state. This represents a total demand of 69.4 million pounds of unshelled nuts.

Continued planting at the average rate between 1960 and 1968 gives a total of 16,032 acres in 1980, a figure consistent with industry expectations. Of this total 12,902 acres would be bearing at a yield estimated at 4,167 pounds per acre. Total production in 1980 is estimated at 53.8 million pounds, well below the potential demand. Acreage and production for Hawaii County are estimated at 80 percent of the state total compared to nearly 100 percent in 1967.

Despite the rapid growth the macadamia nut industry has recently experienced, a greater rate of expansion is possible. Sales promotion on the mainland is essential for this expansion and serious marketing difficulties may develop before 1980 unless mainland outlets are developed.

Coffee

Coffee acreage and production reached a peak in the late 1950's. Acreage declined from about 6,800 acres in 1958, to 4,300 acres in 1970.

Production has declined more than acreage because falling prices have discouraged farmers from fully harvesting their trees. The long life of the coffee plant and the rocky, steep terrain of the coffee land will continue as moderating factors in the decline of coffee acreage.

Several attempts at statistical projections for the coffee industry were unsuccessful. The 1980 projections are based on judgment aided by the 1973 coffee projections developed by the Extension Service in cooperation with the Hawaii County Extension Advisory Council. These reviews and informed judgments suggest a 1980 production of 3 to 4 million pounds from 3,500 acres.

Beef and Veal

Per capita consumption in Hawaii is projected to remain relatively constant between 1967 and 1980 with total consumption of 83 million pounds in 1980. Largely because of limited land, production is expected to increase by only 23 percent in the state and 56 percent in Hawaii County. The area grazed in Hawaii County is expected to remain at the 1967 level of approximately 630,000 acres with shifts to urban and recreational uses balanced by conversion of suitable idle land for grazing. With a strong demand and need for volume production to achieve economies of scale, there is a need for identifying and implementing economically sound land improvements such as water supply, clearing, and weed and brush control.

Sugar

Sugar consumption in the United States is projected to increase 17 percent from 1967 to 1980. The projected increase in production is 7 percent for the state of Hawaii. The area available for expansion of sugarcane acreage in the state is estimated at 18,000 acres above the 237,000 acres devoted to the crop in 1967. This potential increase will be offset by urban expansion and cessation of some of the less profitable operations. Because of replacement of land shifted to urban uses with less productive land, future gains in yields per acre are likely to be smaller than those of the recent past.

For Hawaii County sugar production is projected at 459,000 tons of raw sugar in 1980, or 4 percent above the 1967 level. With the scheduled closing of Kohala Sugar Plantation in 1975, some 13,600 acres will go out of sugar production. This loss is expected to be offset by continued yield increases and some expansion in cane acreage by the other plantations. With the limited productive land area and rising demand, economically sound opportunities for yield-increasing technology should be further explored. The economic feasibility of increased irrigation in Hawaii County should be investigated.

Outlook for Agriculture Beyond 1980

Because of the small size of the study area, it is not feasible to derive reliable estimates of agricultural land use and production for the year 2020 as is the practice for larger regions. The following estimates for the long-term future are based on continuation of existing trends.

Vegetables. Increased production with acreage harvested about 1,000 acres.

Fruits. About 2,000 acres. Additional acreage possible if problems of export restrictions and replanting of papayas are solved, if new fruit crops or improved varieties of existing crops are successfully developed, and if expanded processing outlets are developed.

Macadamia Nuts. Based on U.S. mainland and local demand, 21,000 acres in bearing orchards are feasible by the end of the century with a well-developed marketing program. Foreign competition may become a factor by 1990, but its effect on Hawaii production is difficult to assess at this time.

Grazing Area. Between 500,000 to 600,000 acres compared to some 630,000 acres in 1967.

Sugar. Land in crop unchanged from the approximately 97,500 acres in crop projected for 1980.

Implications for Agricultural Research and Development

Production efficiency. A problem common to most agricultural production in Hawaii County is high cost of labor and materials. At present, this is particularly pressing for temperate crops such as vegetables produced in competition with the mainland. The problem could also become more evident for tropical fruits and sugar if more liberal import policies are adopted for tropical products from foreign countries.

Marketing and cooperatives. Wholesalers and retailers increasingly demand uniform high quality products regularly delivered in dependable quantities. Unless a marketing organization is developed that can meet these requirements, buyers may well turn to competing sources of supply. Macadamia nuts, papayas, and other tropical products are still unfamiliar to many mainland consumers. Market promotion is required to reach the full potential of these products.

New Crops. The history of agriculture in Hawaii reveals a constant search for new crops. While many efforts have failed, macadamia nuts and papayas are examples of recent successes. With 78 percent of the value of agricultural production in Hawaii County for 1968 derived from sugar, it is prudent that the search for new crops and expanded market outlets be continued.

Forest Resources and Related Economic Activities

During the last century, the native forests suffered greatly from uncontrolled grazing and clearing of forest lands for sugarcane and pasture. By the early 1900's the situation had become so acute that forest reserves were established to protect the most critical watersheds. The reserves were fenced, destructive animals reduced in numbers, and tree planting started. Soil and water conservation became the single-use objective of forest land management.

In recent years, Hawaii's rapidly expanding population has intensified the need for the many other benefits that its forests can provide. To meet this need the state is developing a new management policy, directed towards obtaining the most beneficial combinations of goods and services from its lands. Protection will continue to be important, but wisely managed, some lands can produce timber, water, forage, and wildlife simultaneously. Recreation opportunities also can be included in many areas. The potential for multiple-use is not restricted to forest reserves but applies to public and privately owned lands outside the reserves as well. The resource management will include protection of unique biota, geologic, and archeological features.

Extent and Nature of the Resource

Area

The island has more than 58 percent of the forest land and 60 percent of the commercial forest land in the state. The forest land resource on Hawaii includes approximately 1,152,500 acres, or 45 percent of the total land area. Some 567,000 acres are considered commercial forest land--land capable of growing industrial timber crops (Figure 3.2). The remaining forest lands total 585,300 acres, including areas suited for growing timber crops but withdrawn from timber use through statute or administrative regulation. The bulk, while not capable of timber production, is valued for watershed, wildlife recreation, and esthetics.

Fifty-two percent (294,200 acres) of the commercial forest land is state-owned. About 197,200 acres of it is in forest reserves within the Conservation District and are managed under the multiple-use concept. Much of the remaining state-owned commercial forest land, outside the reserves, is leased for cattle grazing and is in the Agriculture District.

The remaining 267,000 acres of the commercial forest land is privately owned. This includes 77,000 acres of private lands which have been in forest reserve status since the turn of the century.

Most of the 585,300 acres of noncommercial forest land is within the Conservation District. Although not suitable for growing timber crops, these lands support tree and shrub cover important for wildlife habitat and watershed protection.

Volume

The volume of sawtimber in native forests and plantations totals over 800 million board feet (Table 3.11). A large part of this timber resource is in native forest types. They occupy nearly 700,000 acres

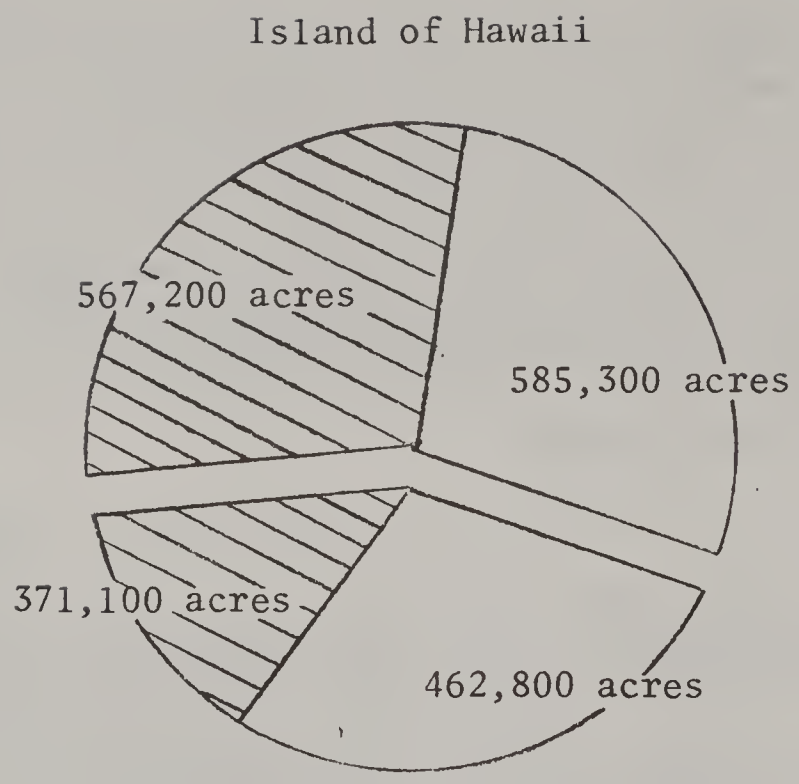


Figure 3.2. Commercial and Non-commercial Forest Land Acreages* on the Island of Hawaii and Other Islands, 1974.**

* Includes federal land in Hawaii Volcanoes National Park which is not included in Conservation Needs Inventory acreages.

** Nelson and Honda, Plantation Timber on the Island of Hawaii--1965, U.S. Forest Service Bulletin PSW-3, 1966, and other U.S. Forest Service Unpublished Data.

of the commercial forest land. The native ohia (Metrosideros collina) sawtimber totals about 570 million board feet, and koa (Acacia koa)--a more valuable species--totals some 185 million board feet.2/ Koa grows to rather large size and produces good quality hardwood. Koa forests were more extensive in the past than they are today. Land clearing, poor cutting practices, and destruction by animals, insects, and fire have all taken a toll.3/ Most of the remaining stands are decadent and poor in form resulting in low per-acre yields. Some foresters believe that if koa is protected and managed, it may perform better than has been generally assumed from the evidence supplied by unmanaged wild forests. Ohia is very widespread and much more abundant than koa. The wood is heavy and hard to work. Grade yields per log are quite high despite the poor form of the tree, but logging is expensive. Due to the low quality of ohia timber, its relatively slow growth and the serious losses to pathogens, insects, or other causes, forest management efforts are being directed toward replacing some decadent stands of ohia with more valuable species.

Planted forests contain a smaller but significant part of the total timber volume. Yields per acre average much greater in planted stands than in native stands. Commercial forest plantations on the island total more than 18,000 acres and contain a total sawtimber volume of 117 million board feet (Table 3.11). About 7,500 acres of these plantations are sawtimber stands. The remainder, some 10,500 acres, are recently planted seedling, sapling, and poletimber stands.

Eucalypts are the principal tree species in older plantations. About 6,300 acres of the sawtimber stands are commercial eucalyptus type of which 4,700 acres are robusta eucalyptus (Eucalyptus robusta). Only about 800 acres are sawtimber size hardwood types other than eucalyptus. Some 300 acres are commercial conifer types.

Recent plantings have emphasized hardwood species other than eucalyptus, i.e., Australian redcedar (Toona australis), Queensland-maple (Flindersia brayleyana), and Tropical ash (Fraxinus uhdei); however, saligna eucalyptus (E. saligna), rosegum (E. grandis) and other promising eucalypts are also widely used. In several recently opened sites, koa has regenerated strongly and its management is being implemented.

2/ Nelson, Robert E., and Philip R. Wheeler, Forest Resources of Hawaii--1961. Forestry Div., Dept. of Land and Natural Resources, State of Hawaii, in coop. with Pacific SW Forest and Range Exp. Sta., Forest Service, USDA, 1963.

3/ Whitesell, Craig D., Silvical Characteristics of Koa (Acacia koa-Gray), Research Paper PSW-16, 1964, Pacific SW Forest and Range Exp. Sta., Forest Service, USDA.

Table 3.11. Volume of Growing Stock and Sawtimber, by Species in Planted* and Native** Sawtimber Stands on Commercial Forest Land, Island of Hawaii, 1965

Species	Growing stock (thousand cubic feet)	Sawtimber (thousand board feet)***
PLANTED STANDS		
Eucalypts		
Robusta eucalyptus	16,830	80,673
Saligna "	2,415	13,895
Kinogum "	286	1,282
Tallowwood "	195	991
Lemon-gum "	142	627
Maiden-gum "	67	249
Blackbutt "	33	175
Gray ironbark eucalyptus	18	96
Deane	30	90
Eucalyptus spp.	2,508	9,717
Total	22,524	107,795
Other hardwoods		
Silk-oak	844	3,191
Tropical ash	464	1,331
Molucca albizzia	221	1,154
Nepal alder	135	497
Jhalna	98	224
Australian redcedar (toon)	23	88
Other hardwoods	234	2
Total	2,019	6,487
Conifers		
Norfolk-Island-pine	274	1,359
Sugi	619	1,181
Redwood	20	94
Western redcedar	20	20
Port-Orford-cedar	5	--
Other conifers	42	12
Total	980	2,666
Total planted stands	25,513	116,948
NATIVE AND NATURALIZED STANDS**		
Ohia	115,331	571,509
Koa	25,218	187,265
Other	303	1,945
Total native and naturalized stands	140,852	760,719
Total growing stock & sawtimber	166,365	877,667

*Nelson & Honda, Plantation Timber on the Island of Hawaii, 1965.
**Unpublished Forest Service data (Institute of Pacific Islands Forestry).
***International 1/4-inch rule.

The state owns 56 percent of the plantation sawtimber--65 million board feet. Most of this--58 million board feet--is located in the Hamakua subbasin south of Waipio Valley and in the Hilo subbasin. In the Ka'u, Kona, and Kohala subbasins, the state owns some 7 million board feet of sawtimber.4/ An additional 16 million board feet of public plantation sawtimber in the Hamakua subbasin is controlled by the Hawaiian Homes Commission.

The bulk of the privately owned plantation sawtimber is also located in the Hilo and Hamakua subbasins--27 million board feet. Only 8 million board feet are in the other subbasins.

The Hawaiian treefern (Cibotium spp.) supports a small but locally important manufacturing industry. Practically all of the treefern resource in the state is on this island. Some 45 percent of the commercial forest land supports treefern, usually in the understory. Though not a lumber species, this useful forest product finds ready markets when processed into planter poles, fern fiber, and carved tikis and it can be managed as part of the forest.

Utilization: Kind, Volume, and Value of Output

Demand

Demands in Hawaii now exceed the present supplies of Hawaii-grown wood products. In 1967, Hawaii's markets consumed about 131 million board feet of lumber and 26 million square feet (3/8-inch basis) of plywood. Hawaii's forests contributed less than 4 million board feet of lumber to this total. The balance came from imports.

In 1963, the U.S. Forest Service, through its Pacific Southwest Forest and Range Experiment Station, joined with the Hawaii Division of Forestry in a marketing research program to evaluate the marketing opportunities for Hawaii wood products. A report5/ prepared under this program estimated that the consumption of lumber in Hawaii by the year 2000 will be between 100 and 123 million board feet for all species. Military demands could possibly double this amount, but the assumption of this estimate for the year 2000 does not reflect the level of military demand for wood products. A corresponding estimate of plywood demand for the year 2000, which also excludes the possibilities of high-military demand levels, is 40 million square feet (3/8-inch basis). This will represent an increase of about three times over the 1960-61 level of plywood consumption (Table 3.12). Most of the lumber and plywood consumed has been softwoods from North America, but significant volumes of Philippine mahogany lumber and plywood are also imported.

4/ Nelson, Robert E., and Nobuo Honda, Plantation Timber on the Island of Hawaii--1965, U.S.F.S. Resource Bull. PSW-3, 1966, Pacific SW Forest and Range Exp. Sta., Forest Service, USDA; and Div. of Forestry, Dept. of Land and Natural Resources, State of Hawaii.

5/ Frazier, George D., Estimated Demand for Lumber and Plywood in Hawaii by the Year 2000, Research Paper PSW-23, 1965, Pacific SW Forest and Range Exp. Sta., Forest Service, USDA.

Table 3.12. Estimated Consumption of Lumber and Plywood in Hawaii, 1950 to Year 2000

Years	Average population	Lumber consumption		Plywood consumption	
		Per capita consumption	Annual avg. consumption	Per capita consumption	Annual avg. consumption
		(bd. ft.)	(million bd. ft.)	(sq. ft., 3/8 in.)	(million sq.ft., 3/8 in.)
1950-52	470,000	170	80	*	*
1956-57	525,000	170	89	3.0	1.6
1960-61	600,000	150	90	21.6	12.9
1980**	865,000	135	117	35.0	30.0
2000**	1,000,000	111	111	40.0	40.0

*Not available.
**Assumes a continued growth in population, and the same trends and proportions of wood product demands between military and civilian sectors as reflected by the 1950 to 1960 period.

Source: Frazier, G. D., K. D. McKenzie, and J. H. Weber. The market potential for Hawaii timber, 1964. The market potential for Hawaii timber resources. A record of marketing research planning, results, and evaluations, 1964. (Unpublished reports on file at Pacific SW. Forest & Range Exp. Sta., U.S. Forest Service, Berkeley, CA.) Interpolation of 1980 per capita consumption and expansion of 1980 estimate made by River Basin Survey Staff. The 1980 population projection was obtained from Water Resources Projection Report, Hawaii Water Resource Region, 1971.

Marketing research has also determined the amount of forest product markets in Hawaii and in selected mainland industries that locally produced hardwoods may hope to capture. For example, at least 6 million board feet of lumber are used in 300,000 pallets each year in Hawaii; all could be made of local wood. There is also a potential annual market of 2 to 4 million board feet of hardwood flooring, close to 2 million board feet of kitchen cabinets, and 6 million board feet of house siding. The Los Angeles furniture market, which consumes over 100 million board feet annually, has traditionally been willing to pay the highest prices for consistent supplies of high quality hardwood products. Because of its proximity to Hawaii, this market may be a major outlet for better quality Hawaii-grown hardwood products in the future.

Output

Primary products from Hawaii's forests support small but locally important manufacturing industries. Sawlogs, craftwood, and veneer logs amounting to 2,512,000 board feet were harvested and milled on the island in 1969. About 55,000 cubic feet of treefern also was processed (Figure 3.3). Other forest products harvested included 840 cords of fuelwood and about 4,900 fence posts.

The value of primary forest products harvested on the island in 1969 is estimated at $208,000.[6/] This is the value of raw material delivered to the mill. The retail value of products manufactured is not known, but it probably exceeds $3 million.

The island's production of primary forest products has ranged between 0.5 and 5 million board feet per acre since the mid 1950's. In recent years the Big Island has produced about 65 percent of the state's annual forest products output.

Present supplies of timber--both planted and native--provide a base for the development and gradual expansion of the local lumber milling industry.

Plantation stands will no doubt be favored by the industry due to their high yields per acre and greater accessibility. Nevertheless, there has been almost continuous cutting of small amounts of koa and ohia, mostly from private lands, over the past 60 years or more. There is little doubt that greater utilization of the native timber resource could come about with improved technology and marketing attendant to an expanded milling operation.

6/ Kind, volume, and value of primary forest products for the island of Hawaii were obtained from data by Robert E. Burgan and Wesley H. C. Wong, Forest Products Harvested in Hawaii--1969, Research Note PSW-239, 1971, Forest Service, USDA.

Two sawmills located in Hilo have a combined annual production capacity of 10 million board feet but have developed markets for only 2 to 3 million board feet. A plywood plant at Kawaihae with a 5-million-square-foot capacity became operational in 1968 and closed a year later due to production and marketing problems. However, as problems are overcome, these mills can be brought up to about one-half of mill capacity--a volume that present resources could support.

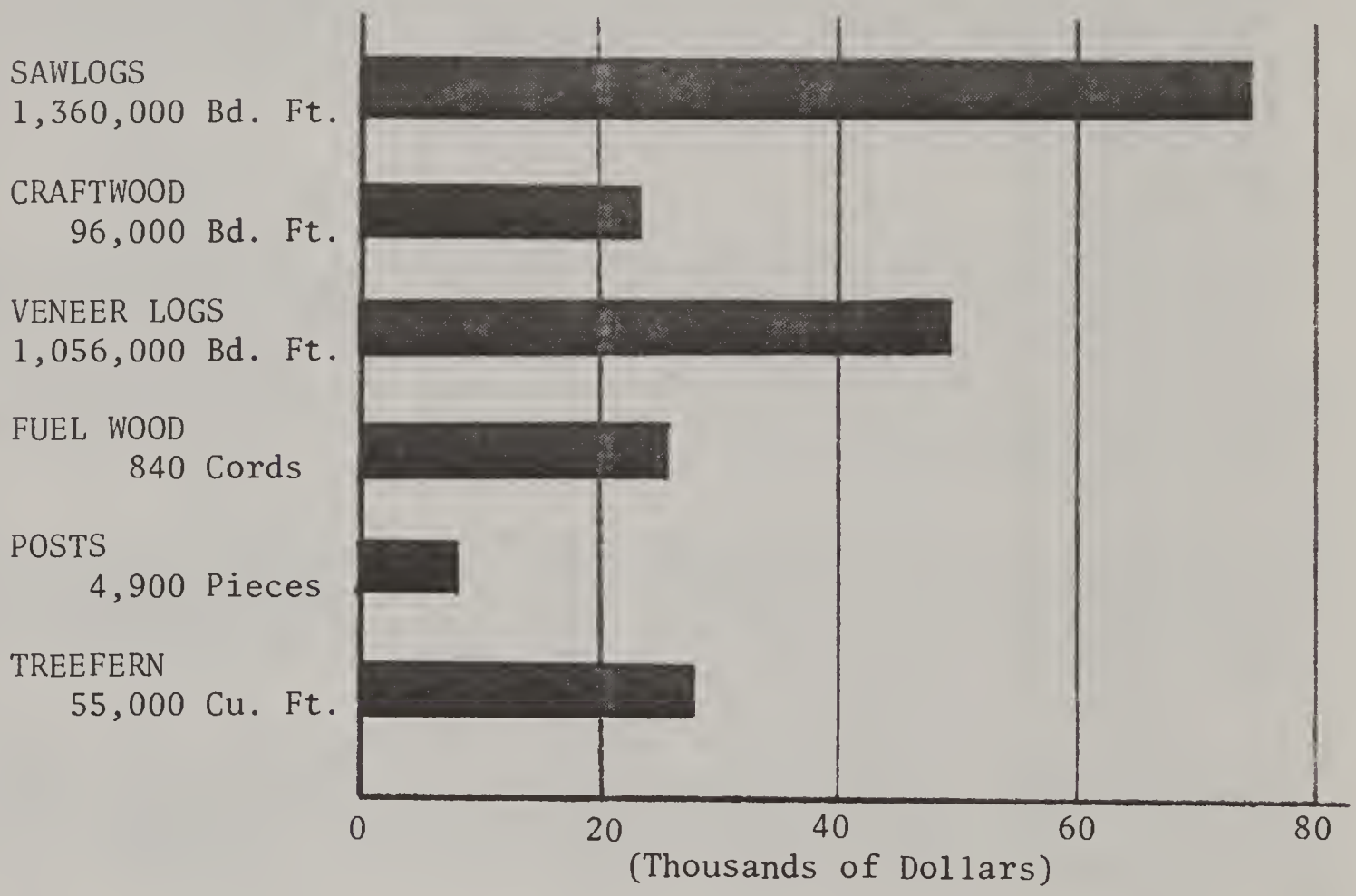


Figure 3.3. Annual Value of Forest Products on the Island of Hawaii, 1969

Current and Projected Growth

The average annual growth of sawtimber in planted stands is 600 board feet per acre or more, but on some sites, growth exceeds 3,000 board feet per acre per year.

The cut over the next 25-year period will remain at a modest level since only the 7,500 acres of older plantations will be available for harvest. By 1995, timber supplies will increase substantially as young plantations from the stepped-up program which started in 1961 reach merchantability. Approximately 1,000 acres per year have been planted under this program. This effort is being continued and hopefully will be expanded on suitable lands including marginal agricultural or grazing lands.

Assuming the 7,500 acres of older plantations would be liquidated over the next 25 years, these stands should support an annual harvest of about 7 million board feet of sawlogs. Native timber could provide additional stumpage during this period. While selected areas of native commercial forest are expected to be withdrawn from timber production and placed in a proposed natural area reserve system and wildlife sanctuaries, it is expected that other koa and ohia stands will be placed under management to improve the yields and quality of these native stands.

If tree plantings were to continue at the rate of 1,000 acres per year, the annual allowable cut could be expected to reach 24 million board feet by the year 2000 and 36 million board feet by 2020.

Outdoor Recreation and Related Economic Activity

Projections indicate a 38 percent population increase between 1970 and 1980 for Hawaii County compared to 22 percent for the state (Table 3.1). In 1965, hotel units in Hawaii County comprised 7 percent of the state total. In 1969, Hawaii County had over 10 percent of the total hotel units and 23 percent of the sum of existing and planned hotel units as of October 1969. These factors indicate that the increase in outdoor recreation participation will be considerably greater in Hawaii County than statewide.

Average summer weekend day participation for 19 different outdoor recreation activities in Hawaii County is estimated for 1967 and 1980 (Table 3.13). The data was adopted and revised for this report from the Comprehensive Outdoor Recreation Plan of the State of Hawaii as detailed in the appendix. By 1980, visitors are expected to outnumber residents in participation in the less vigorous activities of swimming, pleasure driving and sightseeing, walking, sunbathing, attending cultural events, and golf.

The estimates in Table 3.13 are based on 1967 rates of participation for residents and visitors. Future trends in preference or development of attractive facilities and rental of trailers and equipment could greatly increase camping, fishing, horseback riding, and similar activities.

The most likely distribution of projected recreation activities over the island is suggested in Table 3.14. The table shows the expected distribution of population and hotel units in 1980. The bulk of the resident and visitor population will be located in the Hilo and Kona areas, where recreational demands will be the greatest.

Table 3.13. Average Summer Weekend Day Participation in Specified Outdoor Recreation Activities, Island of Hawaii, 1967 and 1980

Activity	1967			1980		
	Residents	Visitors	Total	Residents	Visitors	Total
	Number					
Swimming	4,876	1,188	6,064	7,036	12,845	19,881
Pleasure driving & sightseeing	4,515	1,188	5,703	6,512	12,845	19,375
Playing outdoor sports & games	4,449	20	4,469	6,402	219	6,621
Walking for pleasure	3,831	1,071	4,902	5,527	11,580	17,107
Sunbathing	3,764	1,161	4,925	5,417	12,555	17,972
Picnicking	3,426	*	*	4,944	*	*
Motorcycling/bicycling	3,397	*	*	4,901	*	*
Pleasure boating	2,364	117	2,481	3,410	1,265	4,675
Surfing	2,130	117	2,247	3,071	1,265	4,336
Attending outdoor sports and cultural events	1,559	495	2,054	2,244	5,352	7,596
Hunting	1,423	1	1,424	2,049	6	2,055
Scuba/skin diving	902	72	974	1,301	779	2,080
Fishing	844	54	898	1,218	584	1,802
Biking	621	*	*	895	*	*
Shooting	389	*	*	562	*	*
Camping	357	18	375	513	194	707
Horseback riding	327	*	*	472	*	*
Golf	290	144	434	418	1,570	1,988
Waterskiing	166	20	186	239	219	458

*Data not available. Less than half of the visitors participated in these activities in 1967.

Adapted and revised from Comprehensive Outdoor Recreation Plan, Dept. of Planning and Economic Development, State of Hawaii, published 1970.

Table 3.14. Distribution of Projected 1980 Population and Existing and Planned Hotel Units, Hawaii County

Region	Population	Hotel Units*
	Percent	
North Hilo, South Hilo & Hamakua	54	31
Ka'u and Puna	12	7
North Kohala & South Kohala	10	14
North Kona & South Kona	24	48
Total	100	100

*Sum of existing and planned as of October 1969.
Population: See Table 3.2
Hotel Units: Visitor plant inventory, Hawaii Visitors Bureau, Research Department, October 1969.

Implications for Recreation Research and Development

The projections given in Table 3.14 are based on past trends and could change appreciably. However, a much greater future demand for all types of outdoor recreation is clearly implied. An inventory of the capacity and quality of existing facilities and appraisal of potential sites for further development is also needed. Some work in inventory of existing and potential sites was completed under the Comprehensive Outdoor Recreation Plan, state of Hawaii.

Certain special needs are noted below. Most of these were also reported in the Comprehensive Outdoor Recreation Plan of the state of Hawaii.

Hunting. Provision of an outdoor shooting range to reduce the hazards of uncontrolled target practice and provide opportunities for firearms training and sighting.

Pleasure driving, sightseeing, biking. Preservation and enhancement of scenic values of existing roads and trails. Regulation of use of public trails to avoid conflicts between hikers, horseback riders and motorcyclists. Encouragement of private stables in conjunction with public facilities for horseback riding.

Fishing. Investigations of suitable stocking programs of various inland water bodies with freshwater fish.

Camping and picnicking. Further study of appropriate coordination and balance of upland and shoreline development.

All outdoor recreation activities. Joint planning between public agencies and private interests for meeting outdoor recreation needs of visitors and residents. Assistance to private landowners wishing to develop the recreational potential of their lands including appraisal of economic feasibility, capital needs, and credit availability. Identification of public areas with recreational potential to which access is limited by surrounding private lands and investigation of feasibility of acquiring public rights-of-way.

Relationship of Economic Development and Water Resource Development

For most agricultural products of Hawaii County, economically sound water resource development can help achieve efficiency in production and help close the gap between local and national demand and supply.

All major vegetable producing areas of Hawaii County suffer from periodic drought. The irrigation water supply in the Waimea area has been preempted for domestic uses in times of serious droughts, while other areas are largely unirrigated. Papaya in the Puna area suffers from recurring drought as does sugarcane in the Hamakua area. Other fruits and macadamia nuts would also benefit from a more adequate moisture supply. The opportunities of providing additional grazing capacity through new and improved stockwater supply has been mentioned. It should be stressed that water supply development must offer a favorable rate of return on the investment in order to contribute to more efficient production.

Adequate water supply is also crucial for the rapidly expanding tourist industry, especially in the Kona area. The possibility of development of water conveyance systems that jointly serve population centers and agriculture should be explored, along with the rehabilitation of existing systems.

IV. WATER AND RELATED LAND RESOURCE PROBLEMS

This section discusses the causes, extent, and consequences of various water and related land resource problems on the island. Specific problems identified and summarized include erosion damage, floodwater and sediment damage, impaired drainage, irrigation problems and other water shortages, water pollution, forest management and development, and other environmental problems.

Erosion Hazard

Erosion hazard indicates the susceptibility of soils to erode when protective vegetative cover is removed. Factors that affect erosion hazard are physical properties of the soil including texture and aggregate stability; chemical properties including amount of organic matter and kinds of minerals present; and length and steepness of slope.

In this report the soils are rated as having slight, moderate or severe erosion hazard, and the ratings are shown by colors on the "Erosion Hazard and Present Erosion Rate" map (Figure 4.1). Ratings are for the "great group" level of soil classification. Slope of the land is assumed to be the same for all great groups; thus, only physical and chemical properties of soils are considered in this rating. Many soils on the island have slight erosion hazard due to strong soil structure, high porosity, and aggregate stability. When cultivated or disturbed, these properties are destroyed or altered causing high erosion rates.

Present Erosion Rate

Present erosion rate is an estimate of the average annual amount of erosion that is taking place. In this report it is directly related to land use. Present erosion rate of soils is shown as low, medium, and high on the "Erosion Hazard and Present Erosion Rate" map (Figure 4.1).

Soils used for cultivated crops, including sugarcane and truck crops, have high erosion rates because the soils are exposed to wind and rain between crops. Soils used for pasture, orchard, grazed woodland, and certain forest types grazed by feral animals generally have medium erosion rates. These lands have protective vegetative cover most of the time. Undisturbed forest land, and land such as lava flows that have low content of erodible material, are rated as having low erosion rates.

Within an erosion rate class, the amount of erosion occurring varies considerably due to differences in soil properties, rainfall, slope, and management practices. The wide range in rates indicates that erosion is minimal in some areas and a serious problem in other areas.

FIGURE 4.1

NORTH HALF

EROSION HAZARD AND PRESENT EROSION RATE

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

SEPTEMBER 1973

5 0 5 10 MILES

SCALE 1:400,000

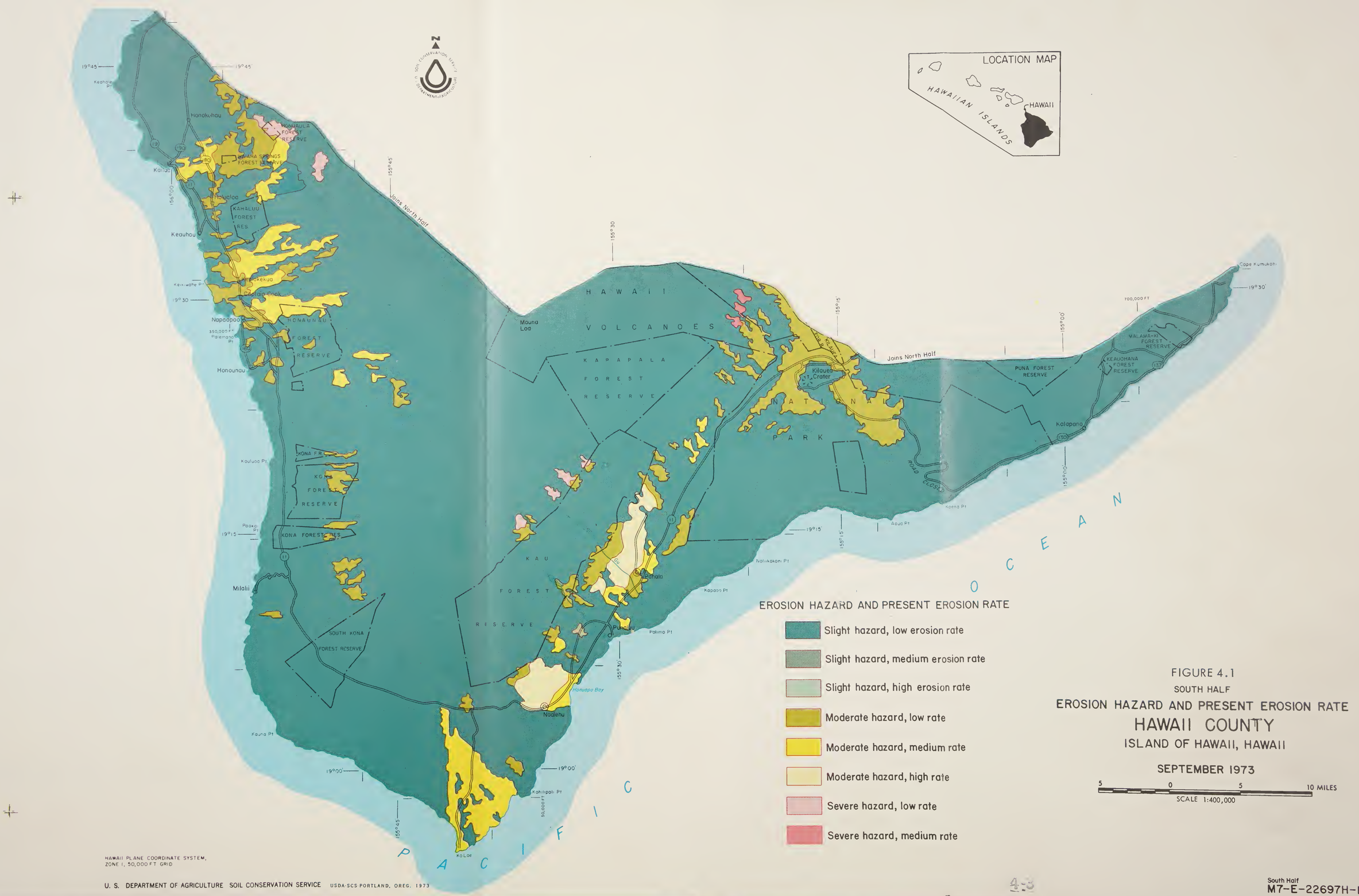
EROSION HAZARD AND PRESENT EROSION RATE

- Slight hazard, low erosion rate
- Slight hazard, medium erosion rate
- Slight hazard, high erosion rate
- Moderate hazard, low rate
- Moderate hazard, medium rate
- Moderate hazard, high rate
- Severe hazard, low rate
- Severe hazard, medium rate

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG., 1973

North Half
M7-E-22697H-N



EROSION HAZARD AND PRESENT EROSION RATE

- Slight hazard, low erosion rate
- Slight hazard, medium erosion rate
- Slight hazard, high erosion rate
- Moderate hazard, low rate
- Moderate hazard, medium rate
- Moderate hazard, high rate
- Severe hazard, low rate
- Severe hazard, medium rate

FIGURE 4.1

SOUTH HALF

EROSION HAZARD AND PRESENT EROSION RATE

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

SEPTEMBER 1973

5 0 5 10 MILES

SCALE 1:400,000

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1973

South Half
M7-E-22697H-N

Low Erosion Rate

Estimated average annual soil loss of less than 1 ton/acre (less than 0.01 inch) is considered in this report to be a low erosion rate.

Undisturbed forests, orchards, and pastures on shallow soils over lava, and nearly barren lava flows are in this erosion rate class. These areas occupy a large part of the island. There is little or no erosion in this class.

Forest soils are well protected by trees and a thick understory of shrubs, ferns, and vines. The soils are permeable with high organic matter content. Surface runoff and erosion are minimal.

Several kinds of disturbances occur within the forests. Feral pigs, sheep, goats, and a few domestic as well as wild cattle are in some forested areas. Some poorly stocked native forests have been cleared by bulldozers and reforested. Small areas have been logged in recent years, and roads have been constructed. Insects and diseases have taken their toll: a recent epidemic is destroying ohia trees on over 200,000 acres on the windward side of the island. Although wildfires are infrequent in the dense rainforest, the number of fires and acreage burned is increasing each year in drier forest areas as more people use the areas for recreation and hunting.

Disturbance of vegetation and soil can lead to increased surface runoff and erosion; however, these effects are often very minor in Hawaii's forests because of year-round growing conditions. Natural recovery is rapid following single-event disturbances, such as removal of vegetation and soil disturbance by logging, fire, sporadic rooting by feral animals, and site preparation for reforestation.

On the other hand, there is evidence that continued or frequently repeated disturbance--such as uncontrolled grazing of forests--often results in greater and longer lasting effects on soil and water supply. Recent research has shown that intensive grazing on Hawaii's moist, heavy-textured forest soils compacts the soil surface so that infiltration is greatly reduced even under good grass cover. Roads, if not properly planned, constructed, and maintained, are another source of serious and long-lasting erosion problems. Many forest roads have excessive grades and inadequate drainage facilities making maintenance difficult and costly.

Many of Hawaii's forest lands will be used more intensively in the future to satisfy expanding needs for hunting, recreation, and wood products. Productivity of the land will need to be maintained and protection of soil and water resources as well as the forest cover will remain a major concern.

Medium Erosion Rate

Estimated average annual soil loss of 1 to 15 tons/acre (0.01 to 0.10 inch) is considered in this report to be medium erosion rate.

Pastures, orchards on deep soil, grazed woodland, and high elevation forest types subject to heavy use by feral animals are in this erosion rate class.

Erosion rates are higher on pastures in dry areas than in wet areas. In dry areas, such as the slopes above 5,000 feet elevation on Mauna Kea and most of the leeward side of the island, vegetation is sparse and soils more exposed to wind and rain. The soils have weak aggregate stability, weak structure, and loose consistence. These soils, therefore, require careful pasture management. Forage production is extremely variable from year to year depending on the rainfall.

Erosion in dry areas is further aggravated by wildfires. Fire causes the spread of undesirable plants in addition to removal of protective vegetation. The spread of fountaingrass, a flammable cover type, is a serious problem in certain areas where repeated burning has occurred.

Forage production is more consistent, and erosion rates are lower in the high rainfall belt in North Kona and on the entire windward side of the island. Soils in these pastures are more clayey and support an excellent grass cover which provides protection from raindrop impact and sheet flow. In some areas, soil compaction caused by intensive grazing has led to reduced infiltration rates and increased runoff. Runoff concentrated in poorly defined drainages on steep slopes has caused gully erosion in pasture and has added to increased erosion, sedimentation, and flooding on cropland and urban land downstream.

Grazed woodlands in high rainfall areas are similar to high rainfall pastures. Much of the woodland canopy has been removed to improve grazing value.

Most orchards on the island are on shallow soils over aa lava and have low erosion rates because of rapid permeability and low content of erodible material. However, some are on deep soils and are in the medium erosion rate class. Since these orchards are cultivated to remove weeds, the soils are periodically exposed to erosion. Erosion in many orchards is reduced by conservation practices such as mulching, permanent grass cover and surface water control measures.

Feral sheep, goats, and pigs can increase erosion by destroying vegetation and disturbing the soil. Serious erosion attributed to feral animals occurs on the upper slopes of Mauna Kea. The native mamani forest ecosystem has been drastically altered apparently by heavy populations of feral sheep. Mamani is a preferred food plant and is heavily browsed--to the extent that the forest cover has been destroyed on many thousands of acres. The loss of forest cover and consequent soil erosion by wind and high intensity rain storms is most severe near the tree line at about 9,400 feet elevation and away from roads where hunting pressure is low.

High Erosion Rate

Estimated average annual soil loss of 15 to 33 tons/acre (0.10 to 0.25 inch) is considered in this report to be high erosion rate.

Sugarcane is the principal crop in this erosion rate class. It is harvested throughout the year on a 20- to 36-month cycle, depending on cane variety and climate. The sugarcane industry is highly mechanized. Harvesting methods consist of burning the cane to remove most of the leaves. A tractor-mounted rake pushes the cane stalks into rows immediately after burning. Large track-type cranes load the stalks onto trucks that transport them to the mill. Fields are subsoiled or disk plowed and harrowed, and seed stalks are machine planted to establish new plantings. Harvesting and replanting operations cause soil disturbance and increase the erosion rate.

Past erosion is not easily recognized since most evidence of erosion is covered by cultivation. Gullies and exposed subsoil, however, are types of evidence that remain.

Soil losses in canefields occur primarily during the first 6 months after harvest, before the new crop develops sufficient canopy to protect the soil. Intense storms during this period cause severe soil losses if measures are not taken to protect the ground surface and control runoff.

Practices that contribute to erosion include cultivation of steep slopes and natural drainageways, and harvesting in large blocks that extend for considerable distances along the slope. Using machinery when the soil is wet compacts the soil and increases runoff.

Sugarcane has been grown in some areas for over 100 years. In 1946, the industry converted from hand harvesting to mechanized harvesting. Residue from the cane was left in the field and protected the soil when sugarcane was hand harvested. Today's mechanized harvesting leaves little or no residue to protect the soil; considerable soil is removed from the field in the harvesting process. Erosion losses estimated at 7.0 to 13.5 tons/acre/year (soil loss of 0.05 to 0.10 inch) is attributed to mechanized harvesting.

Other crops grown on soils in the high erosion rate class are truck crops including lettuce, cabbage, cucumber, tomato, snap beans, and daikon (white radish). Land preparation consists of disk harrowing to chop plant residues, followed by plowing and smoothing. These operations increase soil erodibility by destroying soil structure and removing vegetative cover.

Floodwater and Sediment Damage

From 1911 to 1967, floods claimed at least 18 lives and inflicted extensive damage on the Big Island. Most of these floods were caused by high intensity cold front and Kona storms that normally occur during the winter season (October-April). Periodic tropical storms and rare hurricanes have also caused flooding.

Since most of the towns and agricultural lands are situated in the lowlands, they are susceptible to damage from flash floods and overland flows generated by the torrential rains falling on Hawaii's steep slopes and small drainage areas. Floods have washed out highways and bridges; damaged commercial, industrial, and residential property; disrupted many services; and endangered lives throughout the island. In agricultural areas, floods have damaged and destroyed crops, particularly sugarcane and truck crops, and eroded fields, roads, and pastures. Boulders, gravel, mud, and debris have been deposited on cultivated lands, highways and adjoining properties, and other developments in the flood area.

The 1967 Conservation Needs Inventory of the island's watersheds indicates that 10,400 agricultural acres and over 2,900 urban acres are affected by floodwater and sediment damage. The Hamakua coast, the city of Hilo and vicinity, the Kailua-Kona area, and the Waimea-Kamuela area have been the most seriously affected by floods. However, as development progresses along the coasts and lowlands of Kona, South Kohala, and Ka'u, the potential for serious floodwater and sediment damages in these areas exists. Table 4.1 summarizes some of the more serious floods that have occurred in various parts of the island. While not a complete listing, the table does indicate the extent, magnitude, and frequent occurrence of severe floods on the island.

More detailed coverage of the flood problem in specific areas can be found in the Honokaa Watershed Investigation Report and the North Kona Watershed Early Action Report, which were prepared under this survey.

Impaired Drainage

Although there are 33,000 acres of poorly drained soils on the island, impaired drainage is a minor problem on agricultural lands. Only 100 acres of cropland and 6,000 acres of pastureland are affected by excess water.

Most of these wet areas are found around the northern Kohala Mountain with other small, swampy areas scattered throughout the island. Excess water on these lands usually is caused by shallow, impervious basalt. Bottom lands along the coast or in the valleys of the Kohala Mountain are also subjected to frequent flooding, seepage, and a high water table.

The 1967 Conservation Needs Inventory indicates that all crop and pastureland affected by excess water is adequately treated under present use. The remaining wet areas are used for wildlife habitat and watershed purposes.

Water Shortages

The rainfall of the island of Hawaii varies from 10 to 300 inches annually with an average of 75 inches, or over 5,275 billion gallons of water per year, yet water shortages occur. The problem arises from inequalities in rainfall distribution, great variations in daily and monthly rainfall amounts and recurrent droughts. Adverse geologic and topographic conditions

Table 4.1: Some Major Floods, Island of Hawaii, 1938-1970

Date	Flood Description
April 9, 1938	Hilo's worst storm in 25 years--14.32 inches of rain in 24 hours. Roads, canelands and park damaged.
March 3, 1939	Heaviest 24-hour rainfall in Hilo's history (19.2 inches). Roads and residences damaged.
February 5, 1946	Naalehu Village suffered severe floodwater and sediment damages. Estimated $100,000 damage to roads, residential, commercial, industrial and public property.
November 11, 1948	Hilo receives 10 inches of rain in 12 hours. Extensive residential and crop damage, estimated at $250,000.
January 8-10, 1949	Flooding in Hilo caused an estimated $50,000 damage to roads.
November 16, 1950	Village of Naalehu suffered an estimated $36,000 damage from floodwater and sediment.
August 1958	Severe flood in Waimea-Kamuela area inundated 958 acres. Total damages estimated at $186,380, of which 78 percent ($147,000) was agricultural.
April 2-4, 1961	Cold front storm caused the worst flood in the history of the Hamakua Coast. Devastated area ranged from Papaaloa to Waipio Valley. Total floodwater and sediment damages estimated at $1,910,000, of which 78 percent ($1,499,000) was sustained by the sugar industry.
March 1962	Severe flooding in Pahala area; highway, cane fields, and crops damaged.
April 29, 1963	Village of Kainaliu flooded. Total damages estimated at $52,300, of which 48 percent ($25,000) was agricultural.
July 25, 1966	Flash flood from 17 inches rainfall caused extensive damages in the Alenaio Stream area of Hilo. Damage to public and private property estimated at over $660,000.
April 20, 1968	Heavy rains caused flooding in the Waimea and Kawaihae areas. Total damages to roads and crops estimated at over $170,00,of which 70 percent ($125,000) was agricultural.
October 3-4, 1968	Overland flows due to intense rains caused extensive damage in the Holualoa-Kaumalumalu area of Kona. Total estimated damages to public and private property was $735,000, of which 37 percent ($269,000) was agricultural.

*There were no serious floods in 1969 and 1970.

compound the problem because the island generally lacks suitable sites for large impounding reservoirs and its groundwater resources are costly to develop. Generally, Hawaii has ample water to meet present and projected needs provided proper distribution can be accomplished.

Agricultural Crops

Since only 2 percent or about 10,000 acres of agricultural land is irrigated, practically all of the island's crops rely directly on natural moisture and are affected by periods of low rainfall. Droughts, which annually affect various parts of the island, have resulted in considerable economic loss and concern to the local people. Sugarcane, which is a two- to three-year crop, and pasturelands, which occupy the higher, drier areas, have been most severely affected during these dry periods.

Except for 90 acres of caneland in the Ka'u area, most of the irrigated cropland depends upon Kohala Mountain streams and springs for water. About 9,600 acres of sugarcane along the northeast coast are irrigated, yet water shortages exist due primarily to source limitations, seepage, and evaporation losses. Studies by consulting engineers indicate that the plantations suffer water shortages about 65 percent of the time during the irrigation season and that an additional 10 to 15 million gallons per day (mgd) are needed during peak demand periods. The sugar companies estimate that average annual losses due to drought conditions range from $60,000 to over $500,000 per plantation.

Truck crops near Waimea town comprise the remaining irrigated acreage. The state's Lalamilo Irrigation System provides water for about 200 acres of farmland at Lalamilo, while domestic supplies are periodically used to supplement natural moisture in the Puukapu area, about 2 miles northeast of Kamuela Post Office. Operation studies of the irrigation demands of the Lalamilo farms indicate that the state's system is capable of sustaining crop production on approximately 1,200 acres. An additional 7,500 acres with soils and climatic conditions favorable for intensive agricultural use exist in the Waimea area. However, present irrigation supply facilities would have to be augmented since year-round irrigation is required in this area for successful crop raising.

Although additional storage facilities would greatly increase the water available for agricultural crops, geologic and topographic conditions would render them costly. Source waters in the Kohala Mountain are also limited, with low flows of most streams already committed to existing facilities.

The rest of the island, except the Ka'u area, has no dependable sources of surface water and only brackish ground water in the shoreline zone. While irrigation facilities in these areas are almost nonexistent, some farmers have constructed small, lined catchment reservoirs to carry them through the normally dry months.

Livestock and Rural Domestic

Lack of stockwater has limited animal distribution and upland pasture development on many ranches. Many ranches have relied on isolated catchment and stock-pond systems to meet their stockwater needs, while some smaller ones draw water from the domestic system. Since rainfall catchment is the water source for many ranches, hauling of water has often been necessary during extended dry periods.

Some rural residents, notably those in the Volcano and Glenwood areas and in the southern part of the Kona subbasin, must depend entirely on individual catchment of rainfall and storage tanks. They are affected by recurrent shortages and have had to haul water in for domestic use. Lack of large dependable water sources in these areas has limited the type of development that can occur.

Biennial water shortages have occurred in the Kohala-Hamakua area, and the town of Honokaa has taken water from the sugar irrigation system for domestic use during these times. A recently completed 50-million-gallon, concrete-lined reservoir at Waimea alleviates the present problem. However, additional facilities would be needed to meet future demands if the Waimea and Hamakua areas served by this system experience any great population growth.

Nonagricultural

Generally, the wet windward areas, such as Kohala, Hilo, and Puna, have abundant quantities of surface and ground water for present and foreseeable nonagricultural uses. Since many of these sources are in distant and often inaccessible places, development of these sources and distribution facilities is difficult and costly.

Water deficiency problems are largely centered in the western coastal area extending from Kawaihae to South Point (Ka Lae). Recurrent winter shortages plague the outlying Kona areas which rely mainly on catchment facilities. A series of deep wells (800 feet) tapping basal ground water serves the more populous north Kona area, including the major resort areas around Kailua. County water supply officials report that additional wells are needed to keep up with Kona's recent growth rate, and a new long-range solution to the water problem must be developed.

Water Pollution

General

Water quality has not been a limiting factor in the use of most ground and surface water supplies on Hawaii. Chemical substances in these supplies are well below U.S. Public Health Service recommended limits for potable water and extensive treatment is not needed. However, following State Department of Health recommendations, all public water supplied are chlorinated to destroy pathogenic organisms.

Physical quality is a problem for surface waters originating in forested and heavily vegetated watersheds. These waters are turbid with a yellowish-brown color. The color bodies in the water are organic in nature, derived from humic and tannic acids in decomposing fern and other flora of the watershed. Especially notable have been the Kohala Mountain stream waters which have an objectionable organic taste and are esthetically offensive. A recently constructed water treatment plant at Waimea has overcome these problems.

Salt water intrusion can affect the quality of Hawaii's basal ground water supplies with wells and shafts in coastal areas most susceptible to contamination. The problem has been most pronounced in the leeward areas which have practically no usable surface water and only brackish ground water along the shoreline. Good quality ground water is available further inland but higher ground elevations require deeper and more expensive wells through rock formations and costly pumping to get water to the surface.

Industrial

Present sugarcane harvesting and processing methods result in the discharge of considerable amounts of soil, dissolved sugar, and debris into coastal waters. Highly turbid conditions prevail for distances up to 4 miles from mills which discharge their wastes directly to the sea, notably those along the northeast coast of the island. Characteristics of typical untreated mill wastes are summarized below:

Average Waste Water Characterization of Three Hawaii Sugar Mills*

Suspended Solids	390,000 lbs./day
Settleable Solids	370,000 lbs./day
Chemical Oxygen Demand (COD)	135,000 lbs./day
Total Nitrogen	2,500 lbs./day
Total Phosphorus	1,050 lbs./day
Total Coliforms	4,850,000 organisms/100 ml.
44.5° Coliforms	130,000 organisms/100 ml.

*Source: U.S. Environmental Protection Agency, formerly Federal Water Quality Administration, Hawaii Sugar Waste Study, 1967-1968.

Federal Water Quality Administration studies also disclosed that Hawaii's open waters normally had visibility depths of more than 50 feet and total coliform densities less than 100 organisms/100 ml. In waters affected by the mill discharges, visibility depths decreased to less than a foot near the outfalls and total coliform densities increased to more than 1,000,000 organisms/100 ml. The mill discharges also resulted in reduced coral growths, sludge deposits, and a 70 percent reduction in the number of species and standing crops of fish near the mill sites. Affected waters were thus rendered unsafe or unattractive for fishing, swimming, boating, and other recreational activities.

Present sugarcane harvesting methods, combined with high-intensity rainstorms, also contribute to pollution along the northeast coast. Considerable amounts of soil and debris are periodically transported from open, newly cultivated fields and deposited in coastal waters.

Forest Management and Development

Problems encountered in the forests affect water and related land resources and the forest economy.

While the majority of the forest land is in good hydrologic condition, flooding, erosion, sedimentation, and land resource problems occur in some areas as a result of land clearing, feral animals, range fires, and forest roads.

A forest stand may be well-stocked with brush, trees, or associated vegetation and therein provide adequate watershed protection; but, if the stocking consists of low-grade or cull trees, it will not provide an economic return to the landowner. Watershed protection can just as well be provided by well-managed forest stands, and owner-interest can be stimulated by sales of timber to wood-using industries.

Problems affecting the water and related land resources are divided into four categories:

1. Land Clearing - Native forest types have provided little economic incentive for forest management in the past. As a result, extensive areas of forest land were cleared and converted to caneland and pasture. While the island's economy has benefited from agricultural use of this land, land use changes have not always been in keeping with land and climate capability. Reduced infiltration and accelerated runoff have resulted in some areas. The effect of reduced infiltration on recharge of ground water supplies has not been determined and further study is needed, especially in the high rainfall zone in North Kona where a large part of the native rain forest has been opened for pasture.

   While about 125,000 acres of the grazed open forest land and about 240,000 acres of grassland are capable of producing valuable commercial hardwoods, landowners are apathetic toward growing trees

or improving existing timber stands on portions of their land well-suited for this use. Most landowners fail to realize the possibility of supplementing their income by growing timber with the added opportunities for providing watershed protection, income-producing recreation, and wildlife habitat.

Other uses have held precedence over commercial timber production for several reasons. Perhaps the chief reason is that an awareness of the timber growing potential of Hawaii's forest land began only 15 or 20 years ago. A second reason is that those who administer the land have had no experience with forest management. The tendency of landowners to base their operations on immediate or near future returns is a third deterrent to reforestation on private land.

2. Feral Animals - Feral animals pose serious conservation and management problems if their numbers are not carefully regulated and distributed to protect the soil and to insure perpetuation of native vegetation that developed in the absence of grazing or browsing by hooved animals. Since the early 1800's, the presence of large numbers of these animals in certain areas has had a marked impact on the ecosystem including an effect on rare native wildlife that have evolved interdependently with the vegetation.

Of particular concern is the decline of high elevation mamani (Sophora chrysophylla) and naio (Myoporum sandwicense) forests in the Mauna Kea Forest Reserve-Game Management Area. On many thousands of acres in this 80,000-acre reserve, mamani trees are dying with little or no regrowth. The cause of the decline may be complex including frost, drought, insects, and disease, but most evidence points to overbrowsing and trampling by feral sheep as the primary cause.

Mamani, a preferred food species of the sheep, is a major component of the Mauna Kea vegetation. Even if mamani served no other role, its status as a native tree would make its loss unfortunate. Some biologists believe that preservation of the mamani is the key to the survival of the Palila honeycreeper (Psittirostra bailleui), an endemic bird which is listed as an endangered species.

Moreover, removal of vegetative cover has exposed the soil to wind and water erosion. Esthetic values have also been affected, helping to reduce the desirability of the area for such general recreation activities as hiking and horseback riding.

Feral goat populations are causing similar destruction to native vegetation within the Hawaii Volcanoes National Park on Mauna Loa. Ground disturbance and uprooting of vegetation by feral pigs is apparent in many places; however, because of their adaptability to a wide variety of habitats and less concentrated feeding habits, pigs do not pose as serious a management problem as do sheep and goats.

Feral sheep, goats, and pigs are avidly hunted, and virtually any management program involving reduced numbers is loudly opposed by many sportsmen. Despite problems attributed to feral animals, many sportsmen favor larger and more varied big game populations than now exist. Hunting clubs are sponsoring a proposal to introduce axis deer to the island. The proposal has met with strong opposition from cattlemen, landowners, foresters, and ecologists concerned over possible impacts on other resources.

Possible adverse impacts include competition with domestic livestock for available forage, and damage to agricultural crops and forest plantations, as well as ecological and watershed values. Many conservationists believe that proper control of numbers, through hunting pressure, could be seriously restricted because extensive private ranch lands would remain closed to public hunting.

In view of past history, introduction of nonendemic wildlife species should not be made before full consideration of available forage supply and other economic and social needs--the only logical foundation for determining optimum wildlife numbers. This determination, and the development and administration of a sound wildlife management program will require the cooperation of landowners, game managers, foresters, stockmen, and sportsmen. Only then can the development of additional game resources be consistent with the protection of water and related land resources.

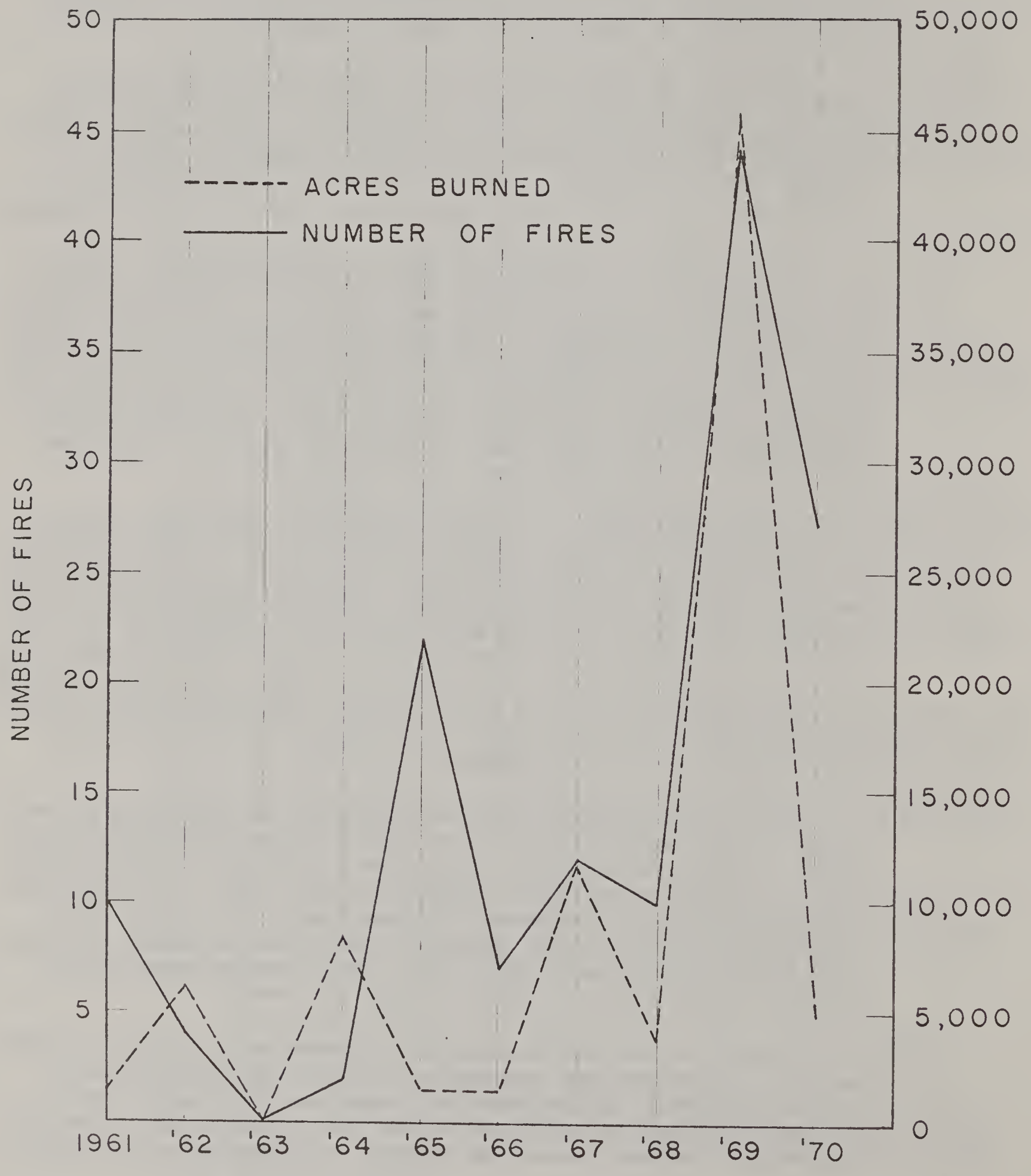
3. Forest and Range Fires - Although forest and range fires have not generally been considered a major problem on Hawaii, the picture is rapidly changing. Hawaii suffered its worst fire season in fiscal year 1969 when 44 wild fires burned a total of 45,710 acres of the island's drier forest and pasture lands. Fire records for the 1961-1970 period indicate that an average of 14 fires occurred each year with an average annual burned acreage of 8,500 acres, most of which was outside forest reserves (Figure 4.2). This represents a 50 percent increase in both incidence and average annual burn acreage over the previous 10-year period.

The risk of potential of fires starting is increasing as new roads and residential subdivisions are developed in hazardous fire areas. Greater numbers of tourists and a growing resident population, with greater mobility and more leisure time, will bring even more recreational development in these areas. New access roads proposed in the arid brush and pastureland areas of North and South Kohala, North and Sounth Kona, Puna, and Ka'u will substantially increase the risk of fire over the next few years.

Hazard, or the availability and flammability of fuels, is also on the increase in some areas as a result of the infestation of undesirable plants following fire. Repeated fires in the lava fields of North Kona and South Kohala have resulted in a change of vegetation from the former low-density, noncommerical forest type

FIGURE 4.2

NUMBER OF FIRES AND ACRES BURNED
ISLAND OF HAWAII
F.Y. 1961 - 1970



to a more hazardous cover of fountain grass (Pennisetum setaceum), a bunchy, erect perennial, 2 to 4 feet high, which cattle will not eat. This grass cures annually, is easily ignited, and provides a continuous fuel with a very rapid rate of spread, making suppression very difficult in the rough terrain. There is no defined "peak" fire season on the Big Island. With the wide variation in climate conditions, serious fires can occur somewhere on the island at any time of the year.

Most fires are man-caused. The most frequent causes are escapes from debris burning, children playing with matches, and careless smokers. Several of the large fires in 1970 were incendiary in origin. Molten lava is a common causal agent during periods of volcanic activity.

Fire prevention, preparedness, and suppression activities have been handicapped by the lack of a fire danger rating system; but researchers have recently developed a system which will enable fire control officers to determine the severity of fire danger on a daily basis.

A major problem in fire suppression is that there are no organized crews specifically and intensively trained to combat range and forest fires. Permanent Division of Forestry personnel are the most effective teams available on wildland fires; however, these men are usually in the field performing regular duties and not available for initial attack. While the county fire department is usually the first to respond, their primary concern is the protection of homes and other physical improvements endangered by the fire. Because they have no off-highway equipment, the county's assistance is limited to fires adjacent to highways or over smooth ground. A District Fire Warden, who is appointed to serve without pay, also participates by rounding up men and equipment needed to respond to fires within his area. However, with the rapid decrease in available agricultural laborers through technological advancements and increased mechanization, a new concept of harder hitting fire attack forces is needed.

There is a need for additional training of supervisory personnel; faster detection; more effective use of helicopters and fixed wing aircraft; improved mutual aid arrangements with the county fire departments; and additional equipment such as radios, pumpers, and special field units.

Trained fire law enforcement specialists are needed to gather evidence and enable vigorous court action to place responsibility for maliciously set fires as well as for those started carelessly by smokers, campers, fireworks users, and trash burners.

Comprehensive fire planning is currently being developed to meet these needs and fire prevention contacts to landowners, resource users, schools, and civic groups are being expanded.

All forest and pastureland resources--whether it be watershed, timber, forage, ranch improvements, outdoor recreation, wildlife, rare endemic plants or esthetic values--are adversely affected by fire. The problem is becoming more critical with the rapidly increasing values of these resources. Soil erosion, flood and sediment damage to lands below, and the introduction of undesirable plants are examples of the negative effects of fire.

4. Forest Roads - Roads are necessary in the use and management of all forest lands and wildlands; yet many forest areas are without roads and many existing roads are very low standard. Excessive grades and inadequate drainage facilities make them impassable or unsafe for all but special four-wheel drive vehicles. Maintenance is difficult and costly and therefore often neglected or inadequate.

Public access to public forest lands on many existing roads is limited by the lack of rights-of-way over adjacent private lands. Furthermore, locked gates in fences which surround the state-owned forest reserve lands, for the purpose of excluding livestock, block public travel on many roads. Improperly located and built roads disrupt natural drainage patterns, provide channels for surface runoff and erosion, require costly maintenance, and reduce the overall esthetic value.

Excessive grades and inadequate surface drainage cause much of the damage. Erosion of the road surface, gutters, and road fills is accelerated where surface runoff is allowed to collect in large amounts and to spill over at uncontrolled points. Where the installation of permanent culverts is not economically feasible, damage could be avoided by "rolling" the grade in broad-based dips at frequent intervals to allow water to drain onto vegetated ground where the sediment can filter out.

Surface erosion and bank sloughing on bare road cuts, another source of sediment during storms, is accelerated when bank toes are undercut by road maintenance equipment.

Too often, substandard roads have been built to serve single-purpose objectives simply because initial construction costs appear cheaper, and little thought is given to future uses or possible damage to other resources. Wherever possible, roads should be well-planned and constructed to meet long-term expected needs for public access and also assure maximum sustained production of forest products and services.

Problems affecting the forest economy include three categories. While having unknown and perhaps insignificant effect on water resources, solution of these problems would represent new opportunity for production or other economic growth.

a. Forest Pests - Destructive pests--insects, diseases, and plants--are an increasing problem. Many were introduced a century or more ago, others are recent introductions, and new pests are discovered at an alarming rate.

Aggressive introduced plants, including banana poka, blackberry, lantana, and firetree, are particularly troublesome. In places they have already taken control of the land.

Twig borers and leaf-eating insects threaten native trees, and stem diseases and root rots have caused extensive losses. Plantation timber has also been affected--recently introduced pine aphids and needle cast fungus diseases have resulted in losses in a number of pine plantations on the island.

Of major concern at present is the apparently accelerating epidemic decline and death of ohia and koa trees over vast acreages, particularly on the windward side of the island. In the Hilo Forest Reserve alone, an important watershed area, some 80,000 of its 120,000 acres are affected, and the area with severely damaged ohia nearly tripled between 1954 and 1965. Extent of damage, rate of spread, cause of the decline, and possible control measures are presently being studied. Preliminary investigations indicate that both insects and diseases are implicated; however, the most probable cause of tree deaths is believed to be Armillaria mellea, a root-rotting fungus capable of killing healthy trees.

No accurate measure of the extent, economic, and social consequences of forest pest losses has been made. Although most native forest is not valuable as a timber resource, it is essential watershed cover and wildlife habitat.

Forest pests also hamper protection and result in unmeasurable loss of unique island environments. Field reconnaissance has indicated no apparent decline in hydrologic condition as dense understory vegetation is seemingly unaffected. Research is needed to determine long-term changes in forest composition, its effect on watershed and wildlife resources, and the program to develop commercial plantation forests.

b. Stocking - Timber growing potential of the island's 567,200 acres of commercial forest land is not being realized because of inadequate stocking.

Stands having 70 percent or more crown cover (approximately 145,000 acres) can be considered fully stocked; however, only if a large percentage of the trees are of merchantable species

and quality. Since the native forests contain a very high proportion of cull trees, little area is adequately stocked with merchantable timber and most stands are inoperable. Of all trees 1 inch d.b.h. or larger, more than three out of every four are cull. These trees, of low value as industrial wood, occupy valuable growing space.

Stands containing less than 1,000 cubic feet (gross) of timber per acre occupy over 70 percent of the commercial forest land. Less than 4,000 acres, or about half of 1 percent, have stands yielding more than 4,000 cubic feet per acre--all in planted forests.

Little is known about the stand volumes that different sites can support; however, few native stands contain as much as 2,000 cubic feet per acre. Under management, these native stands could undoubtedly support greater volumes and the timber quality could be very much improved. On the other hand, volumes in some planted stands exceed 9,500 cubic feet per acre, and these young stands are still growing vigorously.

c. Timber Utilization and Marketing - Logging in native ohia and koa forests is presently unacceptable to many people who prefer to keep the forests in their natural state. Some portions of these forests probably can be held in something close to this state, but despite many years of protection afforded by forest reserve status, many areas are already changing rapidly because of inroads by insects, diseases, and aggressive plants. In some of these areas, logging, followed by intensive cultural treatment, may be the only way to regenerate the native forest.

Less than 2.5 percent of the commercial forest land has been planted to exotic timber species. If an additional 12.5 percent of the commercial forest land presently occupied by unproductive native forest were intensively managed, either for native or exotic species, timber production could, in 30 or 40 years, amount to more than 100 million board feet annually. This is approximately the amount of wood now used (imported) in Hawaii each year.

The major problem in improving timber utilization is in overcoming difficulties in manufacturing and marketing of forest products. The present sawmill industry has a production capacity of 10 million board feet per year but has developed markets for only 2 to 3 million board feet. A plywood plant at Kawaihae with a 5-million-square-foot capacity became operational in 1968, but has remained idle after only one season of operation. Locally produced craftwood is becoming less and less able to comete with imports. More Christmas trees may soon be produced in Hawaii than can be sold, while trees shipped from the mainland continue to dominate the local market.

A recent study of marketing opportunities by the U.S. Forest Service concluded that Hawaii forests can support an expanded forest products industry and local and Pacific Basin markets could support such an expanded industry--provided Hawaii manufacturers can develop the ability to compete with other wood product manufacturers in these markets. Product acceptance will depend upon an ability to produce consistent supplies of products which will substitute in use as well as in quality and price for other products. Finding ways of utilizing pulp and fiber and other by-products as mulches and soil conditioners could greatly improve the outlook. Solving these technical and marketing problems would also reduce the need to burn sawmill leftovers.

Other Environmental Problems

Other environmental problems of the island of Hawaii are not critical when compared with more urbanized, densely populated areas. However, the expected economic growth and population increase would result in increased demands on the island's water and land resources which could easily impair the island's natural beauty.

Smoke from open burning, sugar mills, and power plants causes discomfort and property damage in some communities. The burning of sugarcane prior to harvesting also contributes to air pollution in rural areas, although at infrequent and controlled intervals. Other sources of air pollution include spraying of agricultural chemicals, automotive vehicles, and volcanic smog.

Local wind patterns can cause concentration of air pollutants. In areas sheltered from the tradewinds where local upslope-downslope winds prevail, like the leeward Kona coast, smog conditions could develop as air pollution sources increase.

Disposal of solid wastes in open and burning dumps contributes to air and water pollution in addition to creating unsanitary and unsightly conditions. Illegal dumping of garbage, trash, and other solid wastes into gulches and the ocean, along roadways, and on public and private lands detracts from the natural beauty and also contributes to the pollution problem.

Sewage is untreated and is disposed of in cesspools. About 95 percent of the island's population relies on this method of disposal. Due to the high permeability of the volcanic soils and the presence of numerous underground lava tubes, seepage from cesspools has contributed to pollution of coastal waters and could also contaminate valuable ground water resources. Some older rural communities along the eastern and northern coasts discharge raw sewage directly into coastal waters or streams. This method of disposal also lowers water quality and limits recreational use of these coastal waters.

Excessive noise, especially from low-flying aircraft, is becoming a critical problem in the area near Hilo Airport. Since the economic growth of the county will be accompanied by increased jet service, vehicular traffic, construction, and larger, more dense urban areas, noise levels will more frequently exceed acceptable levels throughout the island.

V. PRESENT AND FUTURE NEEDS FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT

Water resources influence all segments of the island's economy. Development of its principal industries of sugar, cattle raising, diversified agriculture, and tourism is based on a dependable supply of good quality water. Rapidly growing populations, particularly along the western coast of the island, will need more water, while increasing urbanization and development in the lowlands will increase the need for flood prevention and sediment control.

Watershed protection and management measures are needed to increase usable water yield, protect on-site productivity of the soil, and reduce off-site problems of flooding and sedimentation which endanger lives, damage property, and reduce the development potential of lowland areas. Management and control of surface and ground water is also needed to provide adequate supplies for irrigation, stockwater, and rural water needs.

Watershed Protection and Management

Since land surfaces catch water and eventually absorb it by percolation into ground water supplies and streams, the land itself plays a vital role in making water available for beneficial uses. Therefore, the condition of each watershed area determines to a large extent the amount of water that can be developed, the quality of water, and the amount lost as flood flows.

Watershed protection and management measures are needed on cropland, pasture, and forest lands to improve water quality, increase the yield of usable water, and minimize erosion. At the same time, these measures will improve the quality of land resources to meet increasing demands for goods and services.

The application of proper land use and conservation treatment practices will usually result in reduction of the related water problems. Such a program should be based upon the use of each acre within its capability and treatment according to its needs in order to assure a sound agricultural and forest economy, water management program, and quality environment. Table 5.1 summarizes the estimated conservation treatment needs on the island, while the following paragraphs describe the kinds of conservation measures needed for agricultural, forest, and other land.

Cropland

There is a need to provide adequate conservation treatment on 71 percent of the island's cropland. About 94,800 acres of non-irrigated cropland, requires intensive conservation treatment to reduce soil losses and protect the land. Practices such as grassed waterways, terrace construction, diversions, conservation cropping systems, strip cropping, contour farming, and management of crop residue to provide protection of the surface from wind and rain are needed, as well as maintenance or improvement of soil fertility.

Table 5.1. Conservation Treatment Needs
Island of Hawaii, 1967

	Current Acreage1/	Treatment Adequate (acres)	Land Needing Treatment	
			Acres	Percent
Cropland				
Nonirrigated	133,800	39,000	94,800	71
Irrigated	12,000	2,100	9,900	83
Total Crop	(145,800)	(41,100)	(104,700)	(72)
Pasture	468,500	250,000	218,500	47
Forest				
Commercial	704,000	614,000	90,000	13
Noncommercial	316,000	175,000	141,000	45
Total Forest	(1,020,000)	(789,000)	(231,000)	(23)
Other Land				
In Farms	32,200	20,000	12,200	38
Non-in Farms	689,600	639,600	50,000	7
Total Other Land	(721,800)	(659,600)	(62,200)	(9)
Noninventory Land				
Federal Noncropland	201,900	--	--	--
Urban and Built-up	21,000	--	--	--
Total Noninventory Land	(222,900)	--	--	--
Total	2,579,000	1,739,700	616,400	24

1/ Because of differences in definitions and sources of data, acreage figures differ somewhat from corresponding figures cited elsewhere in this report.

Source: Hawaii Conservation Needs Inventory, 1967, and SCS internal data.

Of the 9,900 acres of irrigated cropland needing treatment, 8,400 acres need improved irrigation systems to enable proper application of irrigation water and prevent soil erosion, while 1,500 acres need improved irrigation water management to control soil erosion, to prevent excess water losses, and to time water applications to meet crop needs.

Pasture

Conservation treatment is needed on 47 percent of the pastureland. Proper management practices and grazing systems are needed on some 41,500 acres to improve present forage and provide a satisfactory cover. Another 26,200 acres need brush control measures along with stand improvement. More intensive treatment is needed on the remaining acres where 110,000 acres need vegetative treatment such as reseeding or planting to reestablish vegetative cover, while 40,800 acres require vegetative cover reestablishment with brush control measures.

Forest

Practically all of the water available for use originates in forested portions of the island's watersheds. Since 1904, some 700,000 acres of forest land having primary value as watershed were set aside in forest reserves and more recently included within conservation districts. Watershed protection has been the hallmark of forest policy on these lands and, for the most part, they are in good hydrologic condition. Most forest lands outside the forest reserves are managed for other resources, which generally have taken precedence over, and are sometimes detrimental to, watershed values.

Forest reserve lands, in both state and private ownership, need to be managed more intensively to provide increased goods and services to Hawaii's rapidly expanding population. Forest recreation opportunities need to be expanded. The timber resource must be managed and further developed to provide an increased and sustained wood supply. Grazing can probably be integrated with other uses in some forests to provide additional forage for livestock. There is a growing need to set aside special and unique areas as natural preserves to protect rare and endemic flora and fauna for scientific and educational purposes. Forest wildlife habitats need to be protected and enhanced.

State and private forest lands outside forest reserves need conservation treatment, including land use adjustment, to reduce flood runoff, erosion, and sedimentation, as well as to increase the land's productivity to provide increased goods and services.

Coincident with the need for more intensive use of these principal water-yielding areas to meet the demands of a growing population, is the need for greater efforts in their protection from insect, disease, and plant pests, fire, animals, and man.

Conservation needs estimates for forest land shown in Table 5.1 are based on the need to protect, improve, or establish forests for one or more purposes.

Reforestation to commercial timber species is needed on 6 percent or some 38,000 acres of forest land having soils and climate suited for the production of timber crops. This is the area producing below its potential because of inadequate stocking. Timber stand improvement is needed on 2,000 additional acres of plantation stands.

The area of noncommercial forest land requiring forest establishment or reinforcement to improve nontimber benefits total some 66,000 acres.

More than 25 percent, or 275,000 acres, of the forest land is grazed. Conservation needs on this grazed forest land includes measures to improve forage on about 55,000 acres and reduction or elimination of grazing on 70,000 acres.

Other Land

About 8 percent of the area classified as "other land" in the Conservation Needs Inventory needs conservation treatment. "Other land" includes farmsteads, farm roads, idle land, wildlife areas, and other land not covered by the major inventory classifications.

Of the total acreage in this category, 32,200 acres are in farms and 689,600 acres are not in farms. About 62,200 acres of the total need treatment with soil erosion, the dominant problem. Establishment and maintenance of cover to protect these lands are the most needed conservation measures. Although erosion and infertile soils hamper plant growth in these areas, newly developed techniques could solve treatment problems.

Flood Prevention

Hawaii's unique topographic and climatic conditions render most of the island's lowlands susceptible to flooding by surface runoff. Field reconnaissance revealed that some degree of flood prevention is needed in 14 of the 26 separately delineated watersheds on the island (Figure 8.1).

Flood prevention is a major need in four of these watersheds where recurrent flood damages occur. These watersheds are Wailuku-Alenaio and Honokaa, currently approved for planning under PL-566 legislation; Waiakea-Uka; and North Kona, specifically the Waiaha and Kaumalumalu subwatersheds. Detailed investigations revealed that, although significant annual flood damages occur in all of the watersheds, a favorable benefit-cost ratio was indicated only for the Wailuku-Alenaio watershed.

In the rapidly developing North Kona and Waiakea-Uka watersheds, channel improvements and floodwater diversions are needed to provide flood protection to adjacent lands and to provide suitable outlets for upstream

areas. In addition to structural improvements, flood plain management and zoning are also needed to fully satisfy flood prevention needs and to prevent future flood damages.

A watershed investigation report for Honokaa was published separately. This report presents the detailed investigations of the problems, needs, and alternative opportunities in this watershed.

In the remaining 10 watersheds (North Hawaii, Waipio, North Hamakua, South Hilo, North Puna, Volcano Farms, Ka'u, Waiohinu, Waimea, and South Kona), investigations revealed relatively moderate flood damages which would not justify large expenditures for major flood control measures. Flood prevention needs for these watersheds are less critical but would become more pressing if economic conditions, land needs, and land use change significantly.

The Ka'u, Waimea, and South Kona watersheds have resort and residential developments planned in lowland and coastal areas. These developments could alter the natural terrain and cause flooding by overland flows if they are not carefully planned and controlled. Future flood damages could be prevented by local regulations that would control the development of high damage installations in the flood plains. Flood hazard analyses to provide information on flood heights, areas inundated, flooding frequency, and the extent and nature of possible future flooding are needed for these areas.

Drainage Improvements

No drainage developments are presently needed on the island's agricultural lands. The 100 acres of cropland and 6,000 acres of pastureland affected by excess water are adequately treated under present use. An additional 27,000 acres of wet soils are considered unsuitable for cultivated crops and are devoted to woodland, wildlife habitat, and watershed uses.

Should the pasture areas with wetness problems be changed to cropland, corrective drainage measures would be needed. However, changing land use from cropland and pasture to woodland, wildlife areas, or recreational uses should be considered as an alternate for drainage developments as well as a potential for meeting the needs for these other uses.

Irrigation

Periodic droughts affect all agricultural areas and sometimes inflict severe economic losses. Economically sound irrigation developments can help achieve efficiency and stability in production and also help close the gap between local and national demand and supply.

At the present time, only about 12,000 acres, or 8 percent of the island's cropland, is being irrigated. Of this acreage, the 1967 Conservation Needs Inventory indicates that improved irrigation systems are needed on 8,430 acres. Such measures as additional storage facilities, rehabilitation of existing systems, land leveling, and erosion control measures are

needed for proper application of irrigation water and to prevent soil erosion. In areas with adequate irrigation systems, improved irrigation water management is needed to prevent excess water losses, control soil erosion, and time water applications to meet crop needs. The use of newer subsurface irrigation methods, such as the underground and drip systems that provide constant soil moisture, need to be investigated. These methods could improve irrigation efficiency and enable more acres to be irrigated with the available water.

Rural Domestic and Livestock Water Supply

Rural domestic water is defined as water used for drinking, culinary, and other household purposes in communities of less than 2,500 inhabitants. Most of the island is serviced by county of Hawaii water systems with several communities along the North Hamakua Coast served by private plantation systems. Places without water system service, such as the Glenwood and Volcano areas, rely on rain catchment systems serving individual households.

Although some communities experience shortages during drought periods, rural domestic water supplies are generally adequate except in the Glenwood and Volcano areas where water source developments are needed. The relatively static population of many rural communites indicates that present needs are limited to system replacement and rehabilitation. However, there is a need for improving distribution systems, for installing storage reservoirs or otherwise augmenting surface sources so that systems are more dependable, and for increasing fire protection capacities in some communities.

The island's population is expected to be 87,000 by 1980, a 26 percent increase over the 1970 population. Future growth will probably be concentrated in the Hilo, South Kohala, North Kona, and Ka'u areas where plans for resort-residential developments have been announced. New water sources and systems will be needed in these areas to meet future demands.

Livestock water distribution is inadequate on an estimated 57,000 acres, or about 8 percent of the grazing land in Hawaii County. Stockwater developments and improvements are needed to increase carrying capacities and to enable maximum use of available forage. It is estimated that stockwater improvements on these lands would significantly increase production and could result in an additional 1.5 million pounds of beef available for consumption.

While beef production on the island of Hawaii is expected to increase by 50 percent in 1980, the area grazed is expected to remain at the 1967 level of approximately 743,000 acres, or even decrease slightly. Shifts to recreational and other nonagricultural uses are expected to be accompanied by conversion of suitable idle land for grazing. To maintain the expected increase in beef production, more intensive use of grazing lands will be necessary. Stockwater developments will be needed to increase carrying capacities and to enable the development of new pasture areas. However, stockwater improvement must be accompanied by sound pasture and livestock management practices if the projected 62.6-million-pound gap between statewide consumption and production of beef in 1980 is to be appreciably narrowed.

Municipal and Industrial Water Supply

Surface and ground water adequately supply present municipal and industrial needs on the island. The anticipated growth of the Hilo, South Kohala, North Kona, and Ka'u areas will necessitate the development of new water sources and distribution systems to meet future demands. This need is especially critical in the North Kona area where existing water sources are barely able to meet present demands during drought periods.

Water Quality Control

The State of Hawaii Department of Health investigates all water pollution problems and is responsible for establishing, monitoring, and enforcing quality standards for all waters of the state. Following Department of Health recommendations, nearly all public water supplies are chlorinated or otherwise treated to insure against pollution and contamination. Although surface and ground water is generally of good quality, continued vigilance is needed to protect these sources from natural or man-made pollutants.

Ocean pollution, primarily along the east and north coasts, is the major water quality problem, with sugar mill wastes and sediment the main pollutants. In a few coastal areas, raw sewage and rubbish also contribute to the problem. Efforts are underway to economically control these pollutants that have adversely affected marine life, limited fishing and other recreational uses, and reduced the esthetic quality of the coastal areas.

To meet State Water Quality Standards,7/ direct discharges of floating materials into coastal waters are being phased out and will be ended by the end of 1975. Ocean rubbish dumps operated by the county and the sugar companies are also being phased out. However, suitable disposal areas need to be designated to replace those being eliminated, and the general public should be encouraged to use these areas instead of streams and the ocean.

Sediment and debris from open, newly cultivated fields periodically contribute to pollution along the north and east coasts. Land treatment measures and comprehensive conservation programs are needed to reduce the amount of sediment reaching the ocean and to meet State Water Quality Standards. In lieu of these conservation practices, State Water Quality Standards require that these discharges receive the best practicable treatment or control.

Adequate sewage disposal systems are needed to safeguard public health and maintain water quality. In the highly urbanized and low coastal areas, there is a need for improved sewage collection and treatment systems to replace individual cesspools which could pollute ground water resources. The relatively small discharges of raw sewage into coastal waters have not created serious problems yet. However, this practice violates State Water Quality Standards and should be discontinued. A detailed discussion of sewage disposal problems, needs, and standards is contained in the Sewerage Study for All Urban and Urbanizing Areas of the County of Hawaii, State of Hawaii, December 1970. This report, prepared by professional consultants, is being used by the county for general planning of sewage disposal systems on the island.

7/ Public Health Regulations, Department of Health, State of Hawaii, Chapters 37, 37A and 38.

Environmental Quality Improvement

Although the island's large area and small, scattered population centers make it difficult and costly to monitor and enforce environmental quality standards, it is imperative that the environment be protected and improved. Optimum development of the two major industries, agriculture and tourism, depends upon clean air and water and the island's natural beauty. The island's environmental quality not only enhances life of residents but is also a major economic asset.

More information and research on existing environmental conditions is needed to provide a basis for establishing pollution standards and for measuring future deterioration of the island's environment. Widespread public support of programs and controls to maintain and improve environmental conditions is needed if these preventive measures are to be effective.

Organized refuse collection systems are needed throughout the island. Additional solid waste disposal areas need to be designated on the basis of soil suitability, out of public view, and out of flood-prone areas. Public disposal areas are being converted to sanitary land-fill operations, and ocean dumps are being eliminated to alleviate the pollution problem and comply with the State Water Quality Standards. Along with better collection and disposal systems, stricter enforcement of local and state regulations is needed to prevent unauthorized dumping and reduce unsightly, unsanitary conditions.

Since the island is subject to high-intensity rains which cause flooding and extensive damage, development in flood-prone areas without flood protection should be controlled. Housing and other developments should be restricted or excluded from areas identified as having severe construction limitations such as unstable soils, erosion, or flood hazards. To provide a better environment in urban areas, scenic easements, greenways, conservation and recreation areas, historical sites, and service facilities need to be determined before development progresses.

VI. EXISTING WATER AND RELATED LAND RESOURCE PROJECTS AND PROGRAMS

Several programs already in operation are making significant contributions to the protection and development of the island's water and related land resources. However, it is apparent that progress needs to be accelerated if major objectives are to be met. This is particularly true of the going land treatment programs where the Conservation Needs Inventory reveals that about three-fourths of the agricultural land remains to be treated.

This section describes the levels of development of these programs and their significance in meeting future needs. Specifically covered are USDA programs, other federal agencies, and state programs and projects.

U.S. Department of Agriculture Programs

Public Law 74-46, The Soil Conservation Act

The primary function of the Soil Conservation Service, under Public Law 46 of the 74th Congress, as amended, is to assist landowners, communities, and institutions in planning, applying and maintaining soil and water conservation on their lands. Under this Act, the Soil Conservation Service provides technical assistance through soil and water conservation districts. Five organized soil and water conservation districts cover the island and are active in conservation developments.

Table 6.1 shows the estimated amount of some conservation treatment measures that have been applied on the island of Hawaii. These practices were installed with the assistance of federal, state, and local organizations, and through the efforts of the land owners and operators. Other related activities of the SCS include soil surveys and interpretations, propagation of new conservation plant materials, and providing technical assistance for other USDA programs.

As a part of the National Cooperative Soil Survey, soil surveys in Hawaii were conducted by the Soil Conservation Service. The University of Hawaii's Agricultural Experiment Station and the Hawaiian Sugar Planters' Association jointly provide valuable laboratory data and cooperate in soil classification and correlation. The recently published Soil Survey of the Island of Hawaii, State of Hawaii, contains the detailed soils information.

Besides having valuable agricultural uses, soil surveys can also be used for community and recreational planning. Interpretative maps and reports developed from soil surveys provide an inventory of the soil resources. Soil interpretations for community developments such as homesites, streets, parking areas, cemetery sites, lawns, and commercial areas, and for recreational developments such as golf fairways, playgrounds, picnic, and camping areas are included in these reports. The reports aid in evaluating soil resources by giving alternative uses and suggesting appropriate treatment measures for the land.

Table 6.1. Some Conservation Treatment Measures on the Land as of June 30, 1974, Island of Hawaii

Practice	Unit	Total
Brush Management	Ac.	50,081
Conservation Cropping System	Ac.	77,563
Contour Farming	Ac.	35,011
Crop Residue Use	Ac.	41,287
Diversion	Ft.	2,129,391
Pond	No.	244
Field Windbreak	Ft.	1,613,901
Land Smoothing	Ac.	8,891
Mulching	Ac.	5,781
Irrigation Ditch and Canal Lining	Ft.	200,640
Pasture and Hayland Management	Ac.	655,799
Pasture and Hayland Planting	Ac.	214,863
Streambank Protection	Ft.	6,942
Stream Channel Stabilization	Ft.	7,820
Strip Cropping	Ac.	23,346
Tree Planting	Ac.	25,785
Trough or Tank	No.	754
Wildlife Upland Habitat Management	Ac.	78,991

Source: Internal data, Soil Conservation Service

Single factor interpretative reports and soils maps can also be furnished. These maps are based on only one soil factor such as depth to bedrock, erosion hazard, rocky or stony areas, or other factors that may be desired.

Complete soils descriptions and limitations are contained in the reports. The soils limitations are rated slight, moderate, and severe depending on the seriousness of the limitation as related to a particular land use. These ratings point out potential problems that should be evaluated in the planning stages.

Soils interpretations also are given for engineering uses of soils including physical and chemical properties, depth to bedrock, seasonal water tables, textures of soil horizons, permeability, natural moisture content, and shrink-swell potential.

Since January 1969, nonfarm interpretative reports have been made on approximately 494,000 acres of land on the island.

Public Law 83-566 Projects

The Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, as amended) provides technical and financial assistance to state or local government in planning, designing, and installing watershed improvement works. The Act provides cost sharing for flood prevention, irrigation, drainage, sedimentation control, fish and wildlife developments, and public recreation. It also includes long-term credit to help local interests with their share of the costs, including the costs of developing municipal and industrial water supplies.

Three Public Law-566 watershed projects have been completed on the island. These projects are briefly summarized in the following paragraphs.

Naalehu Watershed Project controls a drainage area of 2,620 acres located in the southern part of the island above the town of Naalehu. Sponsored by the Ka'u Soil and Water Conservation District, the County of Hawaii, and the State Department of Land and Natural Resources, this project was the first to be completed under PL-566 in the state of Hawaii. The project measures installed consist of: (1) Land treatment measures to reduce flood runoff, retard sediment movement, curb erosion, and maintain soil productivity, (2) a debris basin, and (3) 2,610 linear feet of improved stream channel.

The structural measures were installed in August 1966 and, in the following 15-month period, the watershed experienced five storms. These measures successfully prevented flood damages except during the storm of November 1967, when 14 inches of rainfall were recorded in 24 hours. The intense rains caused considerable movement of rocks and boulders that were eventually deposited in the channel causing some overflow. About 3 acres in the flood plain suffered sediment damages. While the structural measures were not damaged, the channel was subsequently extended and the debris basin enlarged to better control future flood flows.

A storm in November 1971 produced 8 inches of rainfall in 24 hours and again caused considerable movement of rocks and boulders. These were trapped in the debris basin. However, deposition of fine sediment in the lower channel reaches caused the stream to overflow its bank and flood a small area of pastureland. The town of Naalehu was not damaged by floodwater, sediment, or debris.

Puukapu Watershed Project controls a drainage area of 9,970 acres above the Waimea community in the northern part of the island. Completed in 1968, the project was sponsored by the Mauna Kea Soil and Water Conservation District, the County of Hawaii, the State Department of Land and Natural Resources, and the State Department of Hawaiian Home Lands.

The works of improvement installed consist of: (1) land treatment measures to minimize runoff and sediment production, maintain favorable soil conditions, and increase irrigation efficiency, (2) a floodwater retarding structure with a dry well outlet system, and (3) a 1,600 feet long floodwater diversion channel. These measures have already protected farms in the benefited area from floodwater and sediment damages during two major storms in 1968 and 1969.

Kona Watershed Project covers an area of 234,800 acres on the leeward side of the island. This project was sponsored by the Kona Soil and Water Conservation District and the county of Hawaii.

The works of improvement consist of: (1) land treatment measures to reduce erosion and flood runoff, minimize sediment production, and maintain soil productivity, (2) a system of floodwater diversion channels and structures above Kainaliu village, and (3) a debris basin and modification of 1,440 linear feet of stream channel in Kailua town. All of the land treatment measures have been applied and the diversion system above Kainaliu and the debris basin and channel improvement in the Kailua area was completed in 1973.

The Act (P1-566) also provides authority for Flood Hazard Analyses. A flood hazard study has been authorized for a portion of the South Kona Watershed. The study area is located between the town of Kealakekua and the Kalahiki Cemetery and is bounded by the Pacific Ocean on the west and extends approximately 2,000 feet mauka of the Mamalahoa Highway. The study area contains approximately 18,000 acres with about nine major drainageways totaling 30 miles. The study is scheduled to be finished in mid-1976.

Public Law 87-703 Projects

The five Big Island Soil and Water Conservation Districts and the County of Hawaii applied for federal assistance under the applicable authorities (P.L. 87-703) for Resource Conservation and Development Program Assistance (RC&D). The project is to be named the Big Island Resource Conservation and Development Project.

The Big Island's application for resource conservation and development assistance is based on the desire of the sponsoring bodies to develop, coordinate, and implement general and specific programs aimed at: (1) strengthening the agricultural industry; (2) improving rural housing, water and sewage systems; (3) accelerating planning and application of conservation land use and treatment; (4) reducing soil erosion, sedimentation, pollution, and flooding; (5) developing new employment opportunities; (6) further developing tourism, recreation, fish and wildlife, and industry potential; (7) alleviating flooding and drainage problems. The application was prepared in 1973 in anticipation of project approval by the USDA Soil Conservation Service under the Food and Agriculture Act of 1962. The application is pending approval at the present time.

Farmers Home Administration

The Farmers Home Administration (FmHA) is a lending agency of the USDA that provides credit and management aid to people in rural areas. Available assistance supplements credit from other sources and includes watershed loans to help local sponsors finance their share of PL-566 project costs, soil and water conservation loans, farm ownership and farm operating loans, rural housing and rural rental housing loans, recreational development loans, and loans to fight rural poverty.

FmHA has contributed considerable financial assistance and advice to island residents. During fiscal year 1974, a total of 155 loans exceeding $2.6 million were made to the local people. The purposes and amounts of these loans are shown in Table 6.2.

Table 6.2. Farmers Home Administration Loans, Island of Hawaii, F.Y. 1970

Type of Loan	Amount
Farm Operating	$ 37,500
Farm Ownership	105,000
Soil and Water Conservation	10,000
Rural Housing	4,470,000
TOTAL	$4,622,500

Agricultural Conservation Program

The Agricultural Stabilization and Conservation Service (ASCS) administers the Agricultural Conservation Program (ACP) through which they share with landowners and operators the cost of installing certain conservation practice.

The County Program Development Group determines which conservation practices are needed within their county and submits a request to the State ACP Development Group for approval of these practices for cost sharing. After approval of each practice, the State Group sets the maximum allowable rate of payments for that practice.

many practices of lasting benefit that might have been foregone without this assistance. The following tabulation shows the conservation cost-sharing payments made by ASCS to participants in Hawaii County over a former 5-year period:

YEAR	NO. OF FARMS	COST SHARE PAYMENTS
1968	164	$ 77,956
1969	133	81,161
1970	85	55,031
1971	81	45,187
1972	95	90,640
TOTALS	558	$349,975

Source: Agricultural Stabilization and Conservation Service, USDA

Cooperative State-Federal Forestry Programs

The U.S. Forest Service is working with the Division of Forestry, Hawaii Department of Land and Natural Resources in seven state-federal cooperative Forestry Programs and a number of forest research projects. The cooperative programs are: (1) Fire Control, (2) Forest Management, (3) Tree Nurseries, (4) Tree Planting, (5) Insect and Disease Control, (6) Forest Products Utilization, and (7) Watershed Protection and Management.

The Cooperative Fire Control Program, authorized by Section 2 of the Clark-McNary Act of 1924, allows the USDA, through the Forest Service, to assist the state and private landowners in providing a satisfactory level of fire protection for nonfederal forest and watershed lands. This assistance is in the form of matching funds for fire protection of nonfederal timberland and, where needed, technical guidance is provided. The goal of this program is to reduce wildfire burn acreage and the resulting watershed damages to an acceptable level on 1,210,790 acres of the island. Federal funds used for this program statewide during F.Y. 1971 were $60,712 out of a total program cost of $188,682.

Under the Cooperative Forest Management Act of 1950, private landowners obtain free technical management advice and assistance on their individual tracts of forest from a Service forester. This professional forester, headquartered in Hilo, is employed and funded by the state with up to 50 percent reimbursement from the federal government. The Service forester promotes better forestry practices on private lands by preparing forest management plans, advising on the marking of timber for sale,

estimating volumes of timber, and supplying information on timber values. He also indicates practices that will benefit wildlife and improve recreational opportunities.

The state provides forest tree seedlings at nominal cost to encourage private landowners to keep their forest land productive. Under this program, authorized by Section 4 of the Clarke-McNary Act of 1924, the state forester operates a central nursery at Kamuela, Hawaii, which provides planting stock for planting on state-owned forest land as well as for private lands. An annual production of about 1 million seedlings is raised under this program. During F.Y. 1971, about 90,000 seedlings were supplied to private landowners for establishment of windbreaks, production of timber crops, and watershed protection. Christmas tree planting is now an active operation among small landowners.

The Forest Service assists state foresters in producing, distributing, and planting trees to build and maintain timber production on good commercial forest land of nonfederal ownership. Under Title IV of the Agricultural Act of 1956, the state forester of Hawaii submitted a plan in 1962 for restocking state-owned forest land. It was approved by the Secretary of Agriculture, and up to 50 percent of the qualifying state expenditures were made eligible for reimbursement from federal funds as appropriated by Congress. In 1971, the Division of Forestry planted 206,000 trees on 527 acres making a total of 11,320 acres of state-owned lands on the Big Island to be planted under the program. The federal government reimbursed the state $30,000 out of the $106,320 total statewide program costs in 1971.

The Forest Service assists the state forester in insect and disease detection and suppression to protect the forests. Under the Forest Pest Control Act of 1947, federal cost-sharing is provided to finance a state forest entomologist, or pathologist, in continuing activities to prevent, detect, evaluate, and suppress insect infestations and disease conditions on nonfederal forest lands. Under the cooperative agreement between the state and the Forest Service, additional federal cost-sharing can also be provided, as funds are available, for presuppression surveys or to suppress forest insect or disease conditions of outbreak proportions on nonfederal lands.

Loggers, primary wood processors, wood users, and forest landowners are given direct technical assistance to improve manufacturing techniques, develop better processing methods, improve use of wood, and to expand markets for wood residue. This technical assistance strengthens rural economy by promoting better use of human and forest resources. To achieve these goals, close coordination and cooperation are necessary among field personnel of the Division of Forestry, Forest Service research scientists, extension foresters, and private agencies engaged in related fields.

The Division of Forestry cooperates with the Forest Service and the Soil Conservation Service in federally sponsored watershed programs which include watershed protection and flood prevention projects and river basin planning activities.

The state also cooperatively supports a comprehensive forestry research program conducted by the Institute of Pacific Islands Forestry, Pacific Southwest Forest and Range Experiment Station, a research unit of the Forest Service. This program provides information required to develop, utilize, and protect the forest and watershed resources of Hawaii.

U.S. Department of the Army Program

Corps of Engineers

The Corps of Engineers, under authority of Section 203, Flood Control Act of 1954, has installed the Wailoa Stream and Tributaries Flood Control Project in the city of Hilo. The project consisting of channel improvements to the Wailoa, Kawili, and Waiakea streams has prevented an estimated $154,000 in flood damages since its completion in 1965. In addition, the Corps of Engineers has completed a flood plain information study for the Kaumana-Punahoa area above Hilo and a flood hazard information study for the island of Hawaii. The Corps also recently initiated an investigation of the water resource needs of the state of Hawaii, specifically in the areas of navigation, flood control, beach erosion, and other related water resource matters.

U.S. Department of the Interior Programs

National Park Service

Two areas occupying nearly 211,000 acres or 8 percent of the island are administered by the National Park Service, U.S. Department of the Interior. The vast Hawaii Volcanoes National Park and the 180-acre City of Refuge National Historical Park annually attract thousands of visitors and contribute greatly to the island's economy. Over 1 million people visited these parks in 1970. Primary management goals for these areas with unique scenic and historic features are to preserve their natural beauty and associated plant and animal life, and to provide interpretive services and facilities for the convenience and safety of visitors.

Bureau of Outdoor Recreation

Land and Water Conservation Fund grants are made based on the Land and Water Conservation Fund Act of 1965 (P.L. 88-578). This program furnishes financial assistance to states and, through them, to their political subdivisions for outdoor recreation planning, land acquisition, and facility development. The program also makes funds available to certain federal agencies for acquiring land and water areas for public outdoor recreation purposes and for preserving wildlife threatened with extinction. The State Department of Planning and Economic Development used planning grants from the BOR to prepare a State Comprehensive Outdoor Recreation Plan.

U.S. Water Resources Council Program

The Level B Hawaii Water Resources Regional Study commenced in July 1973, under the auspices of the U.S. Water Resources Council. The Regional Study is a joint effort by government, industry, and the public to develop a comprehensive Hawaii Water Resources Regional Plan by the end of 1975.

The Regional Plan will consider needs, problems, and opportunities involving Hawaii's water and related land resources. The 1990-2000 decade is the primary target period for the plan, which will:

1. Identify existing and emerging needs, such as flood control, beach protection, water supply development, and recreation.

2. Provide a medium for coordinating federal, state, county, and industry programs.

3. Indicate priorities for public investment in water and related land resources projects.

4. Recommend any needed changes in laws, ordinances, and regulations.

5. Provide for updating and modification in light of changing circumstances.

6. Reflect the needs and desires of the people of Hawaii.

Unprecedented in Hawaii, the multiagency Regional Study involves about 25 federal and 35 state and county agencies. The U.S. Water Resources Council heads up federal participation, while the Hawaii Department of Land and Natural Resources heads state and county participation. Citizens committees will monitor all aspects of the study and advise the study teams concerning the people's needs and desires.

State Programs and Projects

Department of Land and Natural Resources

As the largest landowner in Hawaii County, the state of Hawaii controls over 1,126,000 acres or 44 percent of the island. Most of this state land is administered and managed by the Department of Land and Natural Resources through its various divisions. The conservation, development, and effective utilization of the state's land and other natural resources for the public benefit is the department's broad mission.

The Division of Fish and Game conducts and administers the department's programs for the development, management, and preservation of the fish and wildlife resources of the state. The division has introduced freshwater game fishes into Hawaiian waters and manages the two freshwater fishing areas on the island--the Kohala Public Fishing Area and the Waiakea Public Fishing Area. Five game management areas totaling over 313,000 acres are

also administered by the Division of Fish and Game to provide sportsmen with better hunting opportunities. Major activities include: construction and maintenance of service and hunter access roads and trails, game watering devices, fences, hunter-checking stations, and habitat improvement work. Harvest of game mammals and game birds from these areas in recent years is shown in Table 6.3.

The division also operates propagation facilities and sanctuaries for the restoration and preservation of the nene (Hawaiian Goose) and the koloa (Hawaiian Duck), two endangered wildlife species. In addition, preliminary negotiations are being made with the landowners for the establishment of a cooperative wildlife sanctuary at Opaeula Pond at Makalawena on the Kona coast, an important habitat of the endangered Hawaiian stilt and coot.

The Division of State Parks, Outdoor Recreation, and Historic Sites operates the State Parks Program and the Historic Sites Preservation Program. The major objectives of the Parks Program are the development, operation, and maintenance of park facilities to meet the outdoor recreation needs of the state's resident and visitor population. Toward these ends, the division administers 12 state park areas on Hawaii with diverse features and facilities. The heavy and increasing usage of these areas is shown in Table 6.4.

The objectives of the Historic Sites Preservation Program are the preservation and protection of Hawaii's significant natural, historic, and cultural resources so as to provide opportunities for educational and recreational enjoyment. A statewide survey is currently being made to locate and identify surviving natural areas, historic and cultural buildings, and sites of significant value. Restoration and preservation of major sites and buildings will follow.

The Division of Forestry manages the more than 580,000 acres of state-owned forest land on the island contained within Conservation District zoning. The division also promotes sound forest management on privately owned lands and protects all forest areas from fire, insects, and diseases. Water is the most important resource from much of Hawaii's forest land, and the protection and improvement of watershed areas and water supply are the primary objectives.

Overall objectives are to meet Hawaii's growing needs and to improve the quality of Hawaiian life through protection and management of water, timber, wildlife habitat, and opportunities for recreation on lands under its jurisdiction.

Major programs of the division include: tree planting, nursery operation, timber stand improvement, fire protection, insect and disease control, noxious plant control, administration of timber and forest product sales, recreation, and wildlife habitat management. Forestry programs for the protection and enhancement of important watershed zones, recreation areas, and natural and wildlife habitats are closely coordinated with programs carried on by other divisions within the Department of Land and Natural Resources.

Table 6.3. Game Harvest from Game Management Areas, Island of Hawaii, F.Y. 1966-1970

Species	Years Ending June 30				
	1966	1967	1968	1969	1970
Game Mammals					
Feral pig	143	1,090	481	262	207
Feral goat	7	109	19	27	27
Feral sheep	251	158	1,781	677	1,160
Total - Mammal Harvest	451	1,351	2,281	966*	1,394*
Game Birds					**
Pheasant	484	409	245	233	
Chukar partridge	1,143	970	962	815	
Grey francolin	0	21	43	20	
Quail	443	491	639	534	
Dove	3	2	10	10	
Total - Game Bird Harvest	2,073	1,893	1,899	1,612	**

*No spring hunting season for game mammals in Fiscal Years 1969 and 1970.

**Game bird harvest records incomplete for 1970.

Source: Internal data, Hawaii Division of Fish and Game.

Table 6.4. State Park Areas, Acreage and Usage, Island of Hawaii, 1967-1971

State Park Area (Year Established)	Total Acreage	Developed Acreage	Recreation Visits (1,000)*				
			1967	1968	1969	1970	1971
Akaka Falls State Park (1952)	65	6	108	103	160	153	181
Hapuna Beach State Park (1967)	300	10	-	138	135	288	269
Hikiau Heau State Monument (1967)	2	2	-	-	-	15	16
Hulihee Palace State Monument (1968)	1	1	-	-	19	20	23
Kalopa State Recreation Area (1967)	100	15	-	-	-	-	20
Kilauea State Recreation Area (1966)	7	1	1	1	1	1	1
Lava Tree State Monument (1956)	17	10	70	119	62	46	43
MacKenzie State Park (1955)	13	6	34	62	44	25	29
Manuka State Wayside (1952)	13	8	41	54	72	91	69
Mauna Kea State Park (1962)	700	17	66	75	40	66	78
Wailoa River State Recreation Area (1954)	146	115	380	455	517	682	813
Wailuku River State Recreation Area (1967)	81	15	-	611	539	687	663
TOTALS	1,445	206	700	1,618	1,589	2,075	2,205

* Estimated visits, one person may account for more than one visit.
For years ending June 30. Source: Annual Reports of the Department of Land and Natural Resources, State of Hawaii.

The division maintains a close working relationship with the U.S. Forest Service and receives support from that agency in the form of federal grants for seedling propagation; tree planting; fire, insect, and disease control; technical assistance to forest land owners and wood processors; and in research in the conservation of Hawaii's forest and related resources. These programs are explained in detail under Cooperative State-Federal Forestry Programs on page 6-6.

The Hawaii Forest District (island of Hawaii), one of four districts in the state, is headed by a district forester who is responsible for planning and managing the forest programs within the district. A central nursery located on the island supplies tree seedlings for statewide use in division planting programs as well as for planting on private lands.

The Division of Water and Land Development administers the state's water, land, and mineral resource programs, flood prevention and control program, and also provides administrative support to the state's 15 soil and water conservation districts. Its activities include: data collection and analysis; water resources, research, planning and development; enforcement of the state's water resources statutes and regulations; and project development, construction, and operation.

The division has developed and continually maintains a General Flood Control Plan for the state of Hawaii. It also coordinates the planning and development activities of federal, state, and county agencies, and private interests concerned with water resources problems.

The division has been actively involved in meeting the growing domestic water needs in the Kona and Waimea-Kawaihae areas and has contributed considerable technical and financial assistance to water resource projects on the island. The division also operates and maintains the Waimea-Lalamilo irrigation system, which serves the State Tree Nursery and 26 farmers cultivating 205 acres at Waimea.

The division carries out the statewide water resources planning program under which comprehensive water resources development plans for each of the major islands are being formulated. Planning is progressing in two phases: (1) Inventory of water resources data for the island, and (2) analysis of needs and problems followed by formulation of development plans.

Planning for water resources development is guided by the general premise that water occurring within each service area will be developed to the maximum extent practicable and water will be transferred from one area to another only to supplement locally developed supplies. Development plans consider water supply needs for the present level of population and present land use patterns, while providing for population growth and expansion of the island's economy.

The state's water resources planning program is augmented by matching grants from the U.S. Water Resources Council, under Title III of the Water Resources Planning Act of 1965 (P.L. 89-80), and other federal agencies.

Department of Hawaiian Home Lands

The Department of Hawaiian Home Lands is the state agency that administers the Hawaiian Homes Program, a product of an Act of the U.S. Congress commonly known as the Hawaiian Homes Commission Act, 1920. The Act sets aside land on each of the state's five major islands to make possible the rehabilitation of the native Hawaiian race through a program of homesteading.

On the island of Hawaii, the department manages 110,200 acres of public land in scattered parcels, large and small. As of December 1970, 20,100 acres or 18 percent of the total was being used by the department in its homesteading program. Seventy-seven percent of the total, or 85,200 acres was leased to others, while 4,000 acres, or 4 percent of the total, was not in use. The remaining 900 acres, or less than 1 percent, of the land nominally managed by the department was designated as forest reserves.

Soil and Water Conservation Districts

The districts are entities of the state government and are governed by local boards of directors with administrative support provided by the State Department of Land and Natural Resources. Each independent district plans and establishes cooperative action programs for the conservation, development, and management of its water and soil resources. These local efforts are supplemented and supported by technical and financial assistance from various federal, state, and county agencies.

Five soil and water conservation districts cover the island--Waiakea, Puna, Ka'u, Kona, and Mauna Kea. All have progressive programs underway to provide conservation practices on private lands through cooperative agreements with individual land owners and operators. Through these agreements, land owners and operators receive technical assistance from the Soil Conservation Service and other public agencies for application of conservation practices. These practices control erosion, preserve and improve soil productivity, conserve water, and get full use from soil and water resources. More than 1,100 cooperators with 2,177,000 acres of land have made agreements to participate in the district's programs. Additional district activities include co-sponsoring PL-566 and RC&D project measures and providing assistance to land developers, youth groups, rural committees, and other organizations.

VII. WATER AND RELATED LAND RESOURCE DEVELOPMENT POTENTIAL

This section describes the island of Hawaii's capability to supply water and land resource developments. The island's physical potential for development is discussed in terms of meeting identified needs. Potential developments are not aligned with specific projects or programs but are merely located and identified with appropriate problems and needs. The general categories involved are: availability of land, land use and conservation treatment, water resources development, flood plain management, and recreational developments.

Availability of Land for Potential Agricultural Development

The island of Hawaii is larger than all the other islands combined. Of the 2,584,320 acres, about 690,700 acres or nearly 27 percent of the island is covered with barren lava flows.

Although producing more than half the beef and diversified agricultural crops produced in the state, pasture and truck crops can be expanded to meet the needs of the state's growing resident and visitor population. Expansion of the market for specialty crops such as macadamia, papaya, guava, and exotic flowers and foliages, offers a tremendous potential.

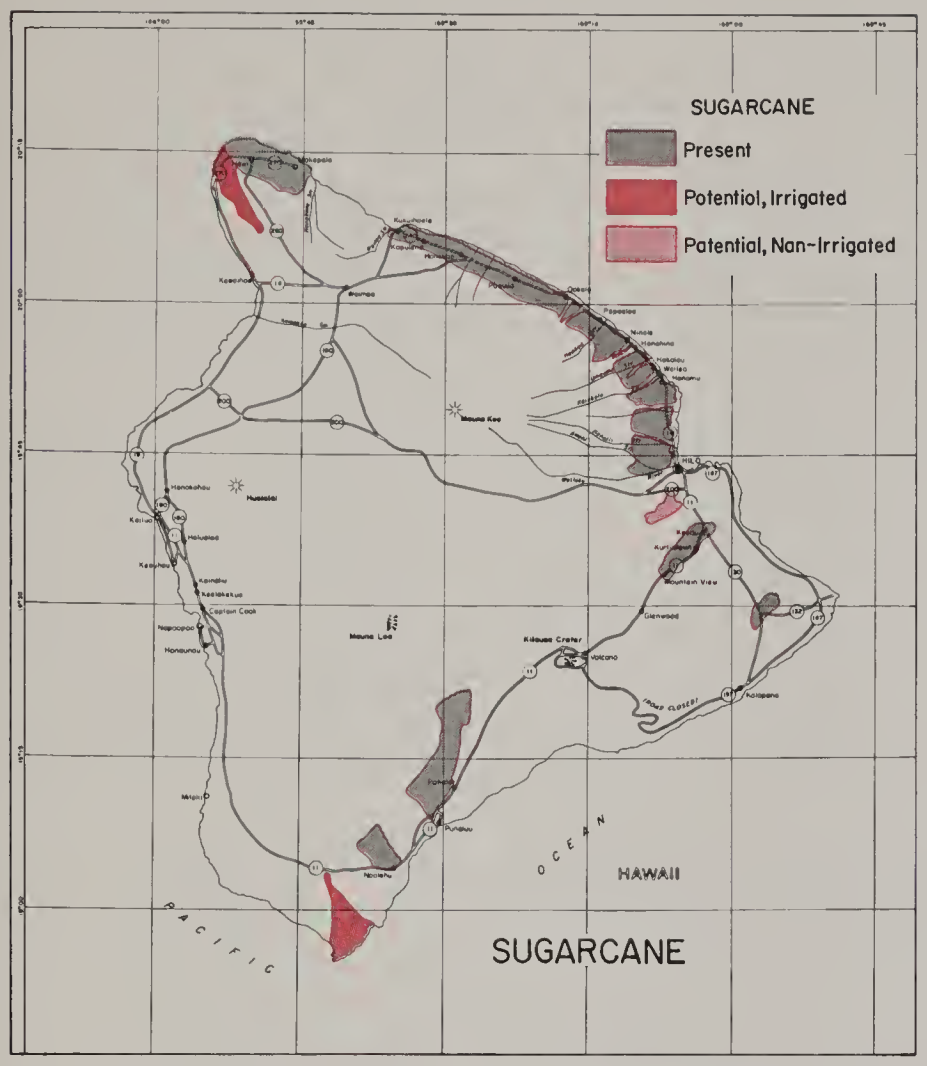
The county is facing increasing pressure to rezone the limited agricultural land to urban use because of the growth in population and economic development. The future prosperity of this island depends on the skillful use of this natural resource.

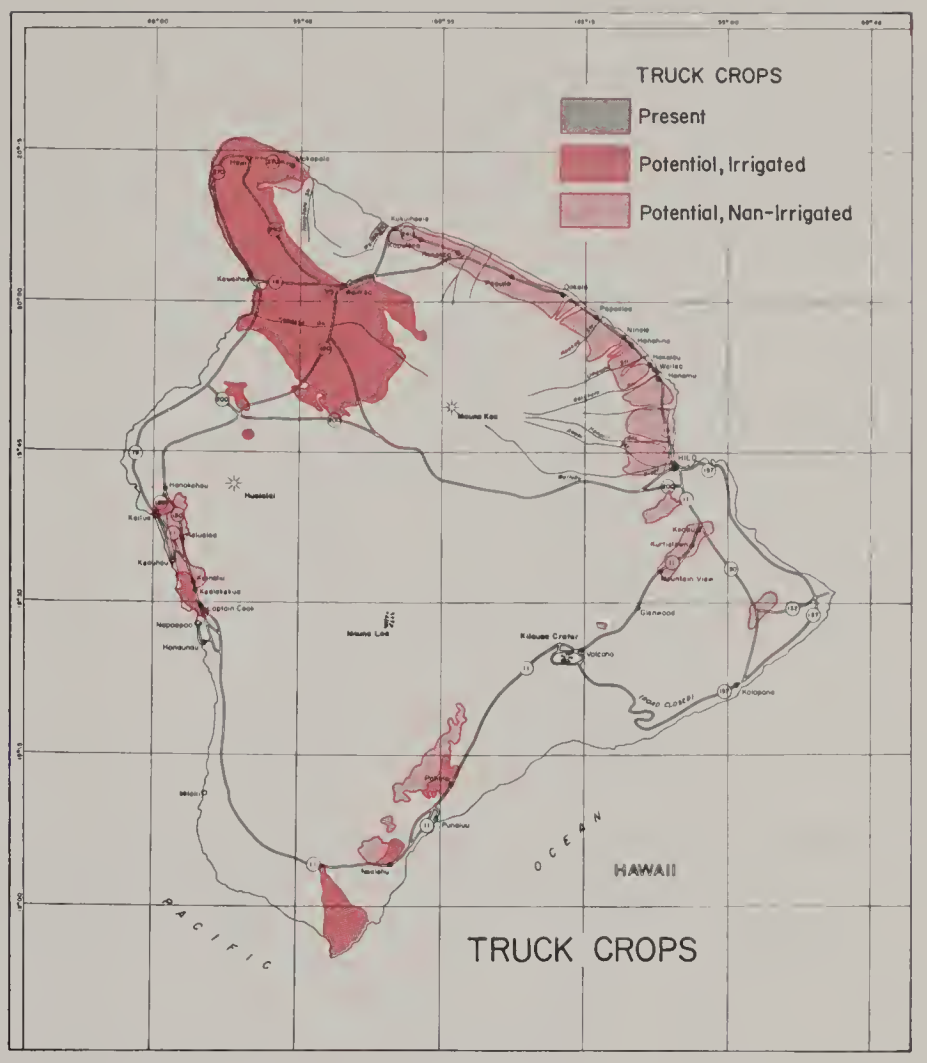
This section attempts to show, in a general way, the areas with potential for truck crops, sugarcane, orchard, and pasture. The potential areas shown on the maps following are not an indication of the best nor most intensive use but illustrate the potential for agricultural development.

Potential for Increased Acreage and Production for Sugarcane

Sugarcane was once grown in Kona, Kawaihae, and Waiakea. Today, it is limited to areas below 1,500 feet along the Hamakua coast and to 3,000 feet in the Ka'u area. Present sugarcane acreage in the island is estimated at 118,000 acres. Limited acres of additional sugarcane can be brought into production since most of the soils are too stony, shallow, or too cold for the present varieties grown. Figure 7.1 shows the present and potential sugarcane areas.

Table 7.1, "Soil Limitation Ratings for Sugarcane," shows the potential acreage for sugarcane based on the land capability classification. Classes I, II, and III were considered to have slight limitation; Class IV, moderate; and Classes VI and VII, severe limitation. Of the 116,000 acres adaptable for nonirrigated sugarcane, 27,000 or 23 percent have severe limitation because of steep slope or stoniness.





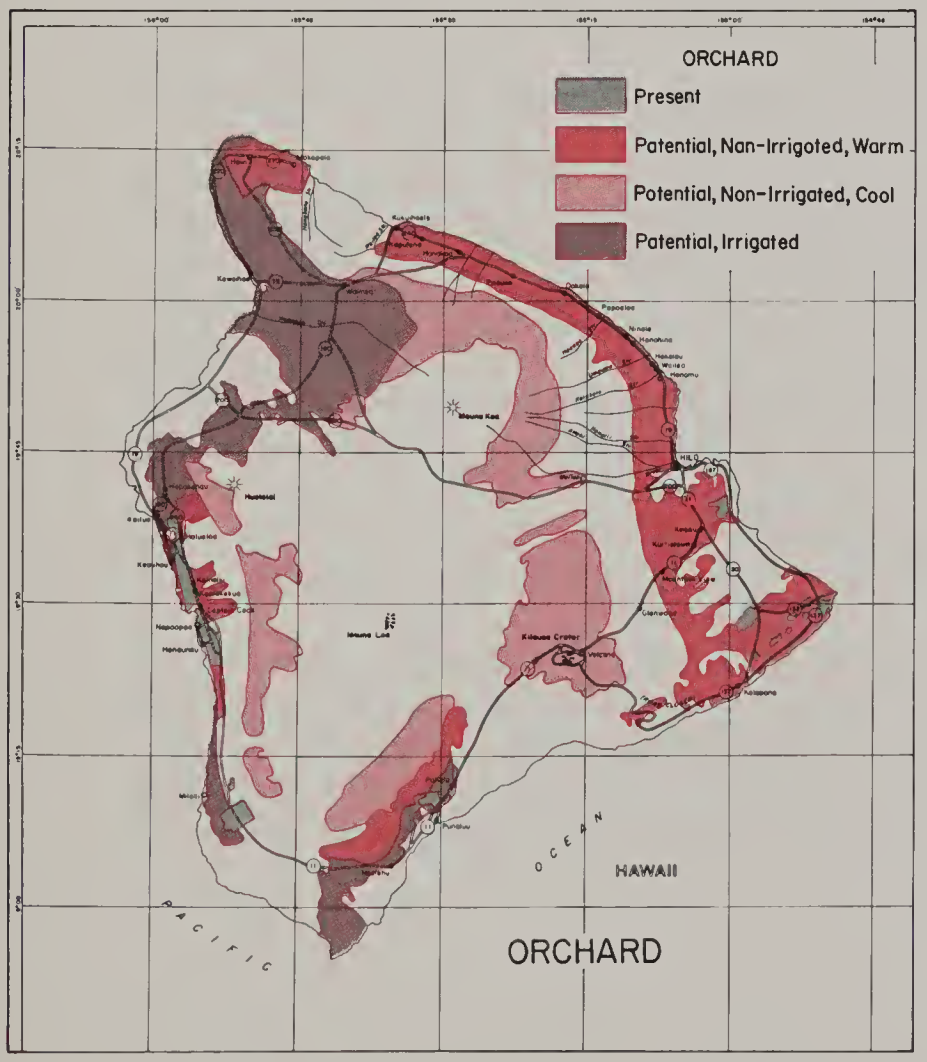


FIGURE 7.1

PRESENT AND POTENTIAL AGRICULTURAL AREAS

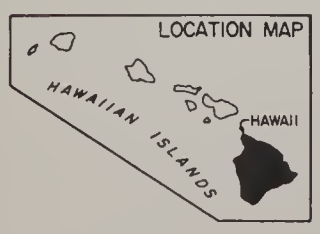
HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

OCTOBER 1973

10 0 10 20 MILES

SCALE 1:1,875,000



U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OREG 1973

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Table 7.1 Soil Limitation Ratings for Sugarcane

Limitation Rating	Acreage Without Irrigation	Acreage With Irrigation	Total
Slight	47,000	25,000	72,000
Moderate	42,000	5,000	47,000
Severe	27,000	11,000	38,000
Potential Sugarcane	116,000	41,000	157,000

Approximately 10,000 acres of sugarcane are presently irrigated, using about 15 million gallons per day (mgd) of water delivered on farms. In addition, about 12,000 acres of nonirrigated sugarcane would benefit from irrigation by an increased yield of about 2 tons per acre. Water requirement for this additional acreage is about 19 mgd. Another 19,000 acres can be brought into production if irrigation water is available. This acreage would require an estimated 63 mgd.

Potential for Increased Acreage for Truck Crops

Truck crops are raised on approximately 2,000 acres in Waimea, Volcano, and Waipio Valley. Scattered small farms are also found in Kona, Puna, and other sections of the island. Figure 7.1 shows the location of the major truck crop areas and the wide range of soil groups in which they are adapted. Although not shown in the map as potential cropland, vine crops such as tomatoes and cucumbers can be grown on the Tropofolists. However, they require specialized management.

Table 7.2, "Soil Limitation Ratings for Truck Crops," shows the potential acreage for truck crops.

Land capability classes were used to rate the soils on their limitations. All soils in Classes I and II were considered to have slight limitation; Class III, moderate; and Class IV, severe. Table 7.2 shows that without irrigation, truck crops can be grown on 137,000 acres. However, more than 50 percent of 83,000 acres have severe limitation.

Table 7.2 Soil Limitation Ratings for Truck Crops

Limitation Rating	Acreage Without Irrigation	Acreage With Irrigation	Total
Slight	13,000	2,000	15,000
Moderate	41,000	66,000	107,000
Severe	83,000	17,000	100,000
Total	137,000	85,000	222,000

If irrigation water is available, 85,000 additional acres can be used for truck crops. Of this, only 2,000 acres have slight limitation and 17,000 acres have severe limitation. On-farm water requirement is estimated at 180 mgd.

Altogether, there are only 15,000 acres with slight limitation when used for truck crops.

Potential for Increased Acreage for Orchards

Macadamia, coffee, papaya, and citrus fruits are the principal orchard crops grown on the island of Hawaii. Although scattered all over the island, the more extensive orchards are in Kona, Ka'u, and Puna. Total acreage presently planted in orchards is estimated at 2,000 acres. Figure 7.1 shows the present and potential orchard areas in Hawaii. Since a wide range of soil and climatic conditions exist on the island, a wide variety of crops can be grown. In general, tropical fruits such as papaya, macadamia, guava, coffee, and passion fruit grow best at elevations below 1,000 feet; citrus at 1,000 to 2,000 feet; and plums, apples and other temperate-zone crops between 4,000 to 6,000 feet.

The soil limitation ratings for orchards rated in Table 7.3 are based on the land capability classes. Classes I through IV were considered to have slight limitation; Class VI, moderate; and Class VII, severe limitation.

Table 7.3 Soil Limitation Ratings for Orchards

Limitation Rating	Acreage with Irrigation	Acreage without Irrigation	Temperate Zone	Total
Slight	53,100	114,900	117,800	285,800
Moderate	15,500	162,600	76,000	254,100
Severe	72,000	33,200	36,900	142,100
Total	140,600	310,700	230,700	682,000

Of the 682,000 acres with potential for orchard, 140,600 acres need irrigation requiring about 366 mgd; 310,700 acres are in low elevation but receive enough rainfall annually; and 230,700 acres are adapted only for temperate-zone crops.

Potential for Increased Acreage and Production of Pasture

Approximately 630,000 acres are used for pasture. They occur from sea level to more than 7,000 feet and receive 5 to 200 inches of rainfall annually. The carrying capacity of these pastures range from 1 acre per animal unit month (aum) to more than 20 acres per aum. Except for the very steep or barren lava flows, almost the entire island has potential for pastureland. The present and potential pastureland is also shown in Figure 7.1.

Table 7.4, "Soil Limitation Ratings for Truck Crops," shows the potential acreage for pasture based on land capability classes. Slight limitation included soils in Class I through IV, moderate limitation was assigned Class VI soils, and severe limitation were soils in Class VII.

Table 7.4 Soil Limitation Ratings for Pasture

Limitation Rating	Acres
Slight	348,000
Moderate	620,000
Severe	193,000
Total	1,161,000

If water is available, about 7,000 acres of pasture can be put under irrigation requiring about 20 mgd. With irrigation and fertilization, the carrying capacity of the pastures in the low rainfall belt can be increased from an average of 10 acres per aum to 1 acre per aum.

Potential for Reducing Erosion Rates on Sugarcane Fields

Present erosion rates on sugarcane fields can be reduced by land treatment measure. While there are no physical conditions that would restrain or limit land treatment, the potential for increasing the rate of application is affected by economic factors and established customs and patterns of farming. Programs that include increased technical assistance, education and information, and cost-sharing in the application of practices could help overcome these restraints.

On the 78,800 acres of sugarcane land needing treatment, an estimated average annual erosion rate of 15 tons per acre is presently occurring. With land treatment measures applied, this annual erosion rate can be reduced to about 6 tons per acre. The major land treatment measures and their costs are shown in Table 7.5.

Table 7.5 Major Land Treatment Measures on Sugarcane Land

Land Treatment Measures	Unit	Quantity	Estimated Cost (Dollars)
Diversion	lineal feet	9,600,000	4,800,000
Cross Slope Farming	acres	48,000	No Cost
Mulching	acres	4,000	680,000
Crop Residue Use	acres	78,800	No Cost
Cover Block Planting	acres	78,800	No Cost

Potential to Preserve Productivity of the Island's Watersheds for Water, Timber, Recreation and Wildlife Habitat

Demand for water is increasing but the accelerated growth, which has increased demand, also has an impact on the watersheds--the sources of the needed water. Large forest areas have been converted to more intensive use--urbanization, cultivated crops, and pasture. While these uses may fall within current soil capability and limitations criteria, recent hydrologic research studies by the U.S. Forest Service show that conversion

of forest land to other uses and intensive grazing of forest lands, have contributed to greater flood runoff and erosion and, therefore, less percolation to recharge the ground water supplies.8/

Yields of usable water can be improved and flood runoff and erosion can be reduced by decreasing the intensity of grazing on steep forested watersheds in the higher rainfall areas. It is expected that the exclusion or reduction of grazing on 70,000 acres of forest land will be facilitated by the trend to greater use of feed lots and more intensive use of pasturelands in areas where such use is compatible with the watershed resource. Reforestation can provide long-term watershed protection for cultivated lands which are too steep or rough to be adequately protected by land treatment measures under cropland use.

Modifying the forest cover to increase fog drip or to decrease losses from evaporation and transpiration also offers some potential for increase in water yields. As more information becomes available, forest management plans can be developed to optimize water yield in critically important water source areas.

Through management practices, forest lands have potential for providing a multitude of products and services needed for economic and social growth in Hawaii.

The development and growth of a local wood products industry can help expand the county's economic base. Although Hawaii's forests now produce less than 3 percent of the state's need for wood products, the physical potential to grow timber crops in Hawaii far exceeds the volume imported. If only 15 percent of the presently little used and unmanaged commercial forest land were managed intensively for timber, production could exceed the present annual forest products consumption of 130 million board feet in about 30 years.

Hawaii's forests provide considerable potential for increased recreation use. Wildland diversity provides opportunities for hiking, camping, mountain climbing, swimming, nature study, horseback riding, hunting, fishing, and scenic tours. The planting of introduced trees and more intensive management of native stands will enhance many forest sites for future recreation development. A well-planned, well-developed system of roads, trails, and other improvements will provide more ready access to this vast resource.

Forest wildlife habitat can be improved by manipulation of the forest cover, thereby increasing the game and nongame resource. However, much remains to be learned about the interactions between wildlife populations and the vegetation to successfully integrate wildlife habitat improvement with the management of other forest resources.

8/ Wood, Hulton B., Land Use and Its Effects on the Hydrologic Characteristics of Some Hawaii Soils; Journal of Soil and Water Conservation, Vol. 26, No. 4, July-August 1971.

The generally unfavorable consequences of forest grazing in Hawaii on forest regeneration and watershed hydrology emphasize the need for special care in using the forage resource. Properly managed, however, some forest types may offer potential for increased livestock production, consistent with other resource values.

Preservation of distinctive biota--especially the rare and endemic flora and fauna--for scientific and educational purposes will be aided by legally designating adequate natural area reserves in representative units of relatively unmodified ecosystems.

Water Resource Development Potential

Potential for Impoundments

Opportunities for development of impounding reservoirs are extremely limited. The island's steep topography, permeable volcanic soils, and narrow valleys with steep sidewalls and streambeds generally preclude economic impoundment of surface runoff. In addition, experience by the State Division of Water and Land Development (DOWALD) has indicated that water developable from individual streams can more economically be stored in artificial reservoirs. Only the Kohala Mountain has both site conditions and supply sources favorable for construction of a major storage dam.

Potential dam and reservoir sites in the Kohala Mountain have been investigated by DOWALD. The physical feasibility of sites on the Kohakohau and Kawainui streams was pointed out in their Water Development Plan for South Kohala - Hamakua, Island of Hawaii, Report R25, dated January 1965. A more detailed study conducted by professional consultants for DOWALD in 1970 demonstrated the engineering and economic feasibility of constructing a dam on Kohakohau Stream. This multiple-purpose reservoir with a storage capacity of 1,800 mg would provide a yield of 10 mgd to meet the domestic, industrial, agricultural, and stockwater needs of the South Kohala District.

Potential for Ground Water Developments

The potential for ground water developments varies throughout the island. Although vast quantities of basal ground water floating on salt water underlie the island, basal water in coastal areas is usually too brackish for beneficial uses. Good quality basal water is available further inland, but its development entails deep wells and costly pumping lifts due to the higher ground elevations. Other types of ground water occurring in lesser amounts are dike impounded water and water perched on relatively impervious soil or rock formations. Ground water trapped by volcanic dike complexes occurs in the rift zones of all five mountains, but only that in the Kohala Mountain is being used; it occurs at great depths elsewhere. The largest supplies of perched water occur in the Ka'u area with smaller amounts found on the wet east and northeast slopes of Mauna Kea and the Kohala Mountain. While the island has ample ground water and highly favorable recharge conditions, recovery of potable water by means of wells or tunnels is adversely affected by the rugged terrain and great depths to the zones of saturation.

More detailed information on the occurrence, availability, and quality of the island's ground water resources are being formulated in the comprehensive water resources development plan for the island of Hawaii to be prepared by DOWALD. Using cost-share funds provided under Title III of the Water Resources Planning Act of 1965, DOWALD will be formulating guidelines for the development of the island's water resources to meet future domestic, agricultural, and industrial needs.

Potential for Channel Work and Levee for Flood Prevention

There is potential for channel work and levee construction to reduce erosion and floodwater damages in four watersheds (Wailuku-Alenaio, Honokaa, Waiakea-Uka, and North Kona).

Because of its youthful geology and porous land makeup, much of the island has not had a chance to develop well-defined stream channels. Only the northeastern slopes of Kohala Mountain and Mauna Kea are deeply incised, with most streams having adequate capacity to contain storm runoff. Except for Waipio Valley, floods in this area are generally attributed to overland sheet flows rather than stream overflow. The rest of the island, especially the South Kohala, North Kona, Ka'u, and North Puna areas, suffers from both stream overflow and overland runoff resulting from the lack of defined channels.

Channel work combined with diversion ditches to intercept overland flows provide the only practical means of controlling floods in areas where drainageways are poorly defined. Channel work could be carried out without major construction problems and would reduce flooding in most rural communities. However, such channel work would also increase stream velocities and gradients, thereby increasing bank erosion. While the unstable stream conditions may not create a major problem in areas with thin soils, a continuing maintenance program would be required and lining of these channels should be considered.

Potential for Flood Plain Management to Reduce Flood Damages

Flood losses can also be reduced or eliminated by local guidance and regulations to restrict developments in flood hazard areas. While opportunities for flood plain management occur throughout the island, application of these management techniques is practical in areas where development is minimal or in developed areas where the flood hazard is not sufficient to justify construction of flood control projects. Because of the rapid urban development occurring in Hilo and Kailua-Kona, zoning, land use controls, and other techniques to restrict development in these areas may be neither economically nor politically feasible. Most of the island has minimal development, and management to control construction of highly demageable values in the path of floods could prevent millions of dollars in future flood losses. In the South Kohala, Kona, and Ka'u areas which are subject to imminent resort-residential development, flood plain management offers the best hope of preventing flood losses.

However, flood-prone areas are often difficult to define since most of the island is so geologically young that streams and appurtenant flood plains have not been formed. On the slopes of Mauna Loa and the west side of the island, random overland runoff can cause severe flooding in areas that do not seem susceptible to floods. Although the lack of defined drainageways makes detailed evaluation of flood hazard areas difficult, the rapid growth of development on the island dictates that emphasis be placed on identifying and preventing further and future flood damages.

The county of Hawaii has recently adopted flood plain management policies calling for the establishment of flood plain regulations to minimize flood losses. These policies are contained in the General Plan for the County of Hawaii, the official policy document for the long-range comprehensive development of the island of Hawaii adopted in December 1971. The General Plan provides the legal basis for subdivision regulations, building codes, health regulations, grading and zoning ordinances, and other regulations. It also provides the county with the legal basis for initiating and authorizing all public improvements and projects.

Land use control in flood hazard areas is the most effective flood plain management measure and can be implemented through zoning ordinances, subdivision regulations, building codes, or the establishment of encroachment lines, greenbelts, and open space floodways. Flood damages can also be reduced by other measures including:

1. Flood proofing which consists of structural changes and adjustments to existing buildings or new construction to reduce or eliminate flood damages.

2. Flood warning system - Timely flood forecasts can be coupled with temporary evacuation of persons and property from the flood plain to save lives and reduce property losses.

3. Permanent evacuation of the flood plain involves public acquisition of lands subject to flooding, removal of improvements, and relocation of the population.

4. Tax adjustments for land dedicated to open space uses and consideration of the flood hazard in building financing can be effective in preserving existing floodways.

5. Flood insurance could provide financial relief to present inhabitants of flood damaged areas where structural or other flood proofing measures are not feasible.

Potential for Water Quality Control

Pollution of ocean waters by sugar mill discharges and sediment from open canefields is the main problem along the Hamakua coast. Improvement of coastal water quality up to the use classifications adopted by the state requires tremendous expenditures and extensive changes in the industry's methods and modes of operation.

The sugar companies along the Hamakua coast are working to meet State Water Quality Standards and will eliminate trash, debris, and floating materials from their mill discharges by the end of 1975. Although the waste water discharges would contain soils which will discolor the ocean, the problem will not be as widespread since some factory operations are being consolidated and six of the mills along the coast will be closed down by the same date. The sugar industry has also developed and recently tested two machines that could further reduce the mills' waste disposal problems. One development, a new type of cane harvester, provides cleaner harvesting with one-third less soil and trash pickup than present methods, thereby reducing the amount entering the factory cleaning plants; while the other, a unique dry cleaner, has shown potential for reducing ocean discharge by 80 percent. Both machines offer opportunity for improved cost economics and sugar recovery, in addition to environmental gains.

Since rainfall is adequate in most sugarcane areas, island plantations are largely unirrigated and recycling of mill waste water is not possible. Consequently, other sugar companies located further inland are using settling ponds and land reclamation projects to dispose of their mill wastes. The Hamakua coast mills, however, are at cliffs edge and have little land available for waste disposal purposes. Industry studies indicate that taking cane land our of production to use as disposal sites would place the companies in a precarious economic position. Research is underway to find the best method of completely removing soil and other foreign matter from the mill water discharged into the ocean.

Although occurring less frequently, sediment pollution of coastal waters resulting from storm runoff can make normal mill discharges seem insignificant. Reduction of sediment pollution is primarily dependent upon a vigorous program to control soil erosion. Sound land treatment practices to improve the infiltration capacity of the soil and maintain permanent vegetation on lands subject to inundation by flood flows would reduce pollution from agricultural sources.

To comply with State Water Quality Standards, direct discharge of raw sewages into Hamakua coast waters is also being phased out and will be eliminated by mid-1977. The raw sewage outfalls are being replaced by either sewage lagoons that provide primary treatment before effluent discharge, or cesspools in the higher inland areas. Other systems that provide primary treatment, such as individual aerobic treatment units, small package plants, or waste stabilization ponds, offer opportunity for replacing individual cesspools that could pollute ground water and recreational resources in coastal areas.

The recently adopted General Plan for the County of Hawaii contains policies and standards for sewage disposal. This document provides the county with the basis for implementing adequate sewage collection and treatment facilities that would minimize sewage pollution of island waters.

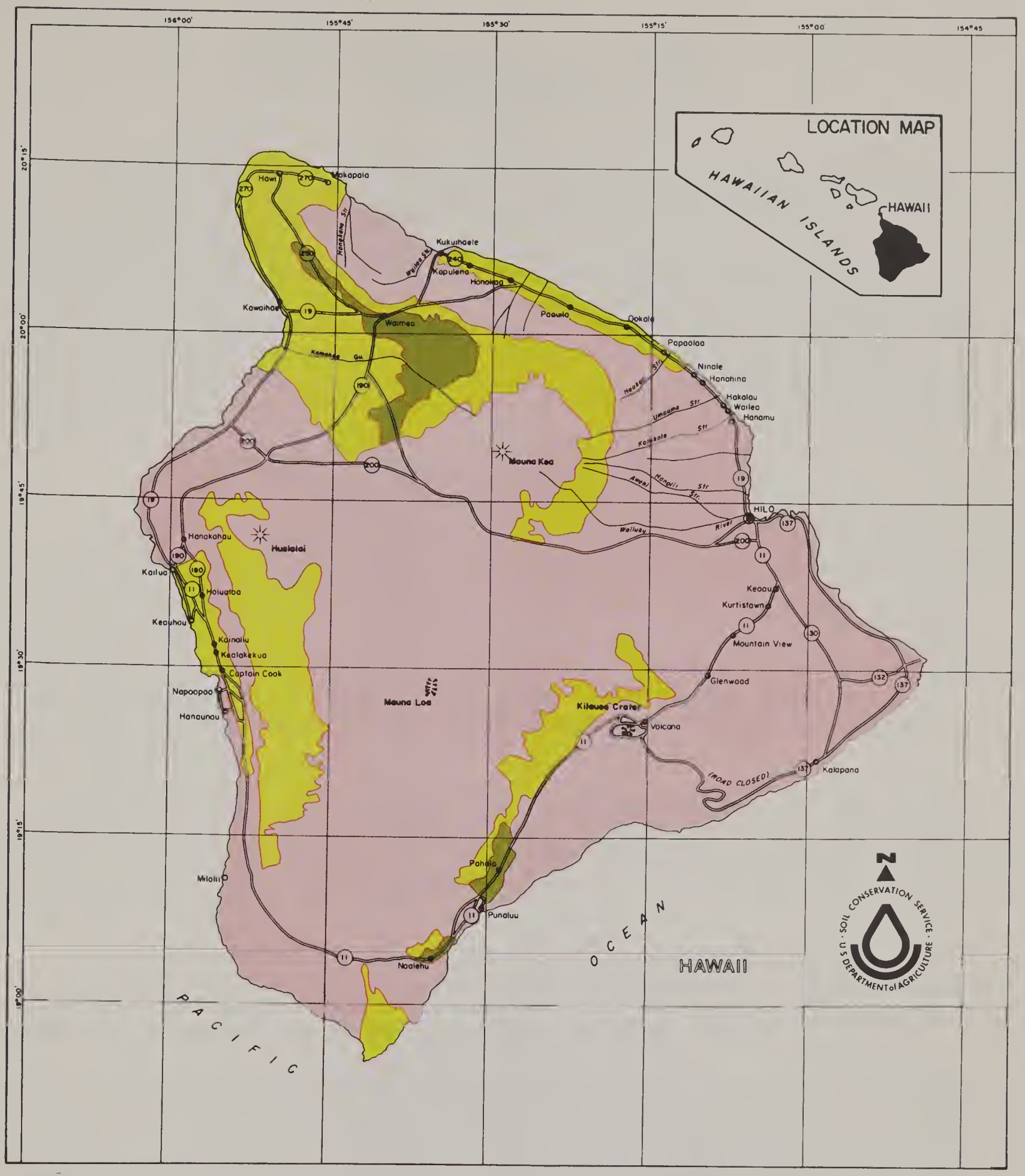
Potential for Recreational Developments

The island's forested and mountainous areas have considerable development potential for land-based recreation activities, such as nature walks, hiking, horseback riding, wilderness camping, picnicking, and active sports. Limited accessibility to many inland areas and restricted public use to protect watershed values have been the main deterrents to expanding recreational development in these areas. Lands within the conservation district have the greatest potential for providing uniquely different experience from those associated with the shoreline.

Suitable inland water bodies are rare and there is only limited potential for water sports. Several streams offer opportunities for limited freshwater fishing. The State Division of Fish and Game, which has surveyed streams throughout the state, has identified 30 streams on the Hamakua coast that merit further consideration. While the streams were evaluated primarily to determine potential areas for public freshwater fishing, many of the areas studied also have significant scenic value and general recreation potential.

The map, "Soil Limitation Ratings for Recreation Use" (Figure 7.2), shows general land areas by their ability to accommodate recreational development. "Slight" limitations indicate most favorable areas, while "severe" indicates areas where recreation development would be more difficult and costly. These generalized areas were determined on the basis of soil suitabilities for recreation buildings, camping areas, paths and trails, picnic areas, and intensive play areas.

The island's excellent physical potential for inland recreational developments is also recognized and discussed in the State Comprehensive Outdoor Recreation Plan (SCORP), published in December 1971. SCORP was prepared by the State of Hawaii Department of Planning and Economic Development, with the aid of professional consultants and a planning grant from the Bureau of Outdoor Recreation (BOR), U.S. Department of the Interior, under the provisions of the Land and Water Conservation Fund Act of 1965 (Public Law 88-578). The plan, which has been approved by the BOR, provides the basis for meeting the recreational needs and demands of Hawaii's residents and visitors, both now and in the future. As a result of the Bureau's approval, the state and the counties are authorized to receive matching federal grants from the Land and Water Conservation Fund for a 4-year period, Dec. 1, 1971 through Nov. 30, 1975. These funds will be used in acquiring lands and developing facilities for outdoor recreation, in accordance with the State Comprehensive Outdoor Recreation Plan.



SOIL LIMITATION RATING
FOR RECREATION USE

- Slight
- Moderate
- Severe

FIGURE 7.2

SOIL LIMITATION RATING
FOR RECREATION USE

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

OCTOBER 1973

10 0 10 20 MILES

SCALE 1:1,000,000

VIII. OPPORTUNITIES FOR DEVELOPMENT OF USDA PROGRAMS

The purpose of USDA participation in this survey is to contribute to the coordinated and orderly development, management, and use of the water and related land resources of the island of Hawaii. This section describes the possibilities for solving identified problems and for meeting anticipated needs through the application of programs administered by USDA. Opportunity exists for initiating new activities and strengthening existing programs and operations that involve water and related land resources. The USDA opportunities can be classed as those relating primarily to group project possibilities, and those relating to the regular operations of the department's resource agencies in carrying out their designated responsibilities.

Flood Prevention and Flood Plain Management under PL 83-566

Although some degree of flood prevention is needed in 14 watersheds, investigations indicate that only the Wailuku-Alenaio watershed has potential for development under the authority of the Watershed Protection and Flood Prevention Act (PL-566, 83d Congress, as amended). The remaining 13 watersheds have very low or no potential for development under PL-566, unless significant changes in economic conditions, land needs, or land use occur. The watershed status map (Figure 8.1) shows flood problem areas on the island and Table 8.1 summarizes reconnaissance data for all the island's watersheds.

Several factors limit the PL-566 project opportunities on the island. These include: (1) minor or moderate flood damages with the cost of flood control exceeding the benefits, (2) problems that can be solved by local group action or other current programs, and (3) a limited population or number of agricultural units within an area.

A brief discussion of the Wailuku-Alenaio Watershed Project follows. The watershed contains 167,000 acres, of which 93 percent is state owned and 7 percent is privately owned. The northern part of the city of Hilo is located at the lower end of the watershed. Sugarcane is grown on 3,800 acres (2.3 percent of the watershed) above and adjacent to urban areas. Sugar is the main agricultural product with an average annual crop value of $1.9 million. Woodland occupies 46 percent of the watershed in the middle and upper elevations above the canefields--most of which is zoned as forest and watershed reserves. Pasturelands in the upper watershed areas outside the forest reserves occupy 21 percent of the watershed, and barren lava and cinder lands on high mountain slopes cover nearly 30 percent.

The primary problems are floodwater, sediment, and erosion damages, occurring on cultivated and urban lands in the vicinity of Hilo, where most of the private land is located. Approximately 1,900 people and 475 ownership units are affected by floods. Annually, there is direct floodwater damage of $313,500, sediment damage of $95,300, and erosion damage of $47,400 in the watershed.

FIGURE 8.1

NORTH HALF

WATERSHED STATUS

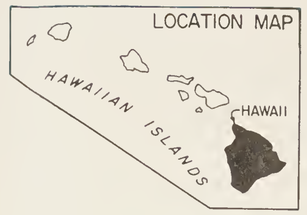
HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

MARCH 1973

5 0 5 10 MILES

SCALE 1:400,000



WATERSHED STATUS

- Subbasin Boundary
- Watershed Boundary
- Subwatershed Boundary
- Flood Problem Area
- Project completed under PL-566
- PL-566 project under construction
- Feasible PL-566

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID

8-2

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND, OREG. 1973

North Half
M7-E-22697J-N

FIGURE 8.1

SOUTH HALF

WATERSHED STATUS

HAWAII COUNTY

ISLAND OF HAWAII, HAWAII

MARCH 1973

5 0 5 10 MILES

SCALE 1:400,000

HAWAII PLANE COORDINATE SYSTEM, ZONE 1, 50,000 FT GRID.

8-3

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS-PORTLAND OREG. 1973

South Half
M7-EN-22697J

TABLE 8.1 -- Summary of Watershed Reconnaissance Data, Island of Hawaii

No.*	Name	Area (Acres) Main WS	Area (Acres) Sub-WS	Population Areas With Flood Problem	Major Watershed Needs	Feasible PL-566 Project Yes	Feasible PL-566 Project No	Remarks
HAMAKUA SUB-BASIN								
811	North Hawaii	83,000		Hawi, Kapaau	Flood protection, watershed treatment		X	Minor flood damages; limited benefits.
811.1	Waipio Valley		14,600	Waipio Valley	Flood protection		X	Preliminary investigation in 1958 indicated project not feasible.
812	North Hamakua	154,500		Kukuihaele	Watershed treatment, coastal water qoality		X	Minor flood damages; limited benefits.
812.1	Honokaa		12,600	Honokaa, Haina	Flood protection, watershed treatment		X	B-C ratio not tavorable.
HILO SUB-BASIN								
821	South Hamakua	146,000		Laupahoehoe	Flood protection, watershed treatment, coastal water quality		X	Minor flood damages; limited benefits.
822	Wailuku	112,500		Hilo	Flood protection, watershed treatment	X		822 and 823.1 combined, being planned under PL-566.
823	South Hilo	181,500		Hilo	Flood protection, recreation, fish and wildlife		X	Corps of Engineers flood control project completed.
823.1	Alenaio		73,500	Hilo	Flood protection	X		Being planned under PL-566 with 822.
823.2	Waiakea-Uka		85,000	Hilo	Flood protection, recreation, fish and wildlife		X	
824	North Puna	215,000		Glenwood, Pahoa	Flood protection, rural water		X	Minor flood damages; limited benefits.
KA'U SUB-BASIN								
831	South Puna	122,000		None	Rural water		X	Aboot 58,000 acres in Hawaii Volcanoes National Park.
832	Kilauea	164,500		None	Rural water		X	Aboot 110,000 acres in Hawaii Volcanoes National Park.
832.1	Volcano Farms		25,500	Volcano Farm Lots	Flood protection, rural water		X	Possible groop action project; limited benefits.
833	Ka'u	232,000		Pahala	Watershed treatment, recreation		X	Limited benefits; 29,000 acres of National Park land.
834	Naalehu	92,500		None	None		X	
834.1	Naalehu Village		2,620	Naalehu	Flood protection, watershed treatment	X		PL-566 flood prevention program completed.
834.2	Waiohinu		1,900	Waiohinu	Flood protection, watershed treatment		X	Preliminary investigation in 1968 indicated project not feasible.
KONA SUB-BASIN								
841	South Hawaii	98,000		None	Rural water		X	
842	South Kona	160,000		None	Rural water, flood protection		X	
843	North Kona	224,000		None	Rural water, flood protection		X	
843.1	Kailua Area		193,000	Kailua, Kalhalilu Kealakekua	Flood protection, watershed treatment, irrigation, rural water	X		PL-566 flood prevention project completed.
KOHALA SUB-BASIN								
851	Puu Waawaa	175,000		None	None		X	
852	Waikii	218,000		None	Watershed treatment		X	
853	Waimea	155,000		Puako	Flood protection, watershed treatment		X	Limited benefits outside 853.1.
853.1	Punkapu		9,970	Waimea-Kamuela	Flood protection, irrigation	X		PL-566 flood prevention program.
854	Mahukona	39,500		None	Rural water, watershed treatment		X	

*Watershed Identification Code - Used by State of Hawaii Division of Water and Land Development and by SCS.

Preliminary investigations indicated that a 2.5 mile system of floodwater diversion channels and appurtenant structures would be economically feasible. Other alternatives, such as stream channel work and outlet channels with recreational aspects, are also being investigated.

The Soil Conservation Service also conducts flood hazard analyses under the authority of PL 83-566, as amended. The State of Hawaii and the Soil Conservation Service have signed a Joint Coordination Agreement for a Flood Hazard Analyses and Flood Plain Studies within the state. This agreement outlines the objectives and responsibilities for completing flood hazard analyses and related flood plain studies. These studies will provide information on existing and potential flood problems for local governments to develop sound flood plain management and land use programs. A study has been authorized for a portion of the South Kona Watershed. Other areas needing a similar study are portions of the Kohala and Ka'u sub-basins.

Other USDA Group Authorities

In addition to the PL-566 project opportunities, several other group water and related land resource development programs are applicable on the island. These are smaller in scope than PL-566 projects and usually involve groups of two or more land operators. Assistance would include cost sharing through pooling agreements, FmHA group loans, and the regular group enterprise technical assistance programs available to the soil and water conservation districts through USDA agencies.

These authorities have been actively used in the past for group projects involving storm drainage, irrigation structures, stockwater ponds, and stream channel work. While needs for this type of work still exist, more detailed studies will be needed to fully appraise the potential.

Resource Conservation and Development Projects

The Food and Agriculture Act of 1962 (Public Law 87-703) authorized the Secretary of Agriculture to cooperate with federal, state, and other public agencies, and assist in developing plans with the people of an area. These plans are identified as Resource Conservation and Development (RC&D) Projects.

While there is no RC&D project on the island, the program can be used to help local people improve the overall economic and social conditions and to develop, utilize, and conserve the natural and human resources of the area. This can be accomplished through coordinating and accelerating current resource programs, authorizing new programs, and stimulating local people to individual and group action. RC&D projects are locally initiated, sponsored, directed, and controlled. Agencies and organizations that give assistance to an RC&D project work as a team under the direction of local leadership.

USDA provides technical and financial assistance to the local groups in their resource conservation and development efforts. The Soil Conservation Service has leadership for USDA in this program and helps project sponsors seek funds and services from other federal agencies and from state and local sources.

Since RC&D is basically a "self-help" program, strong local leadership and involvement of all interests--rural, urban, suburban--are needed to achieve project objectives. It is believed that the nucleus for such a project exists on the island and a coordinating mechanism, such as RC&D, could prove invaluable in carrying out planned, locally initiated projects.

The island's five soil and water conservation districts, the county government and numerous rural, community service, and businessmen's organizations could provide the needed local leadership. In addition, the comprehensive General Plan for the County of Hawaii, the policy document for the long-range development of the island, provides the direction for balanced growth and could be a basis for RC&D project efforts. An application for RC&D Program assistance was submitted to SCS in late 1973.

Land Treatment under PL-46

Needed land treatment measures can be installed with assistance provided under Public Law 46 and related authorities. Under the provisions of this law, technical assistance is furnished by the Soil Conservation Service through the soil and water conservation districts. This technical assistance is usually supplied for the development of conservation plans for farm and ranch units that set forth land use alternatives concerned with erosion, drainage, flood prevention, and pasture improvement.

Five soil and water conservation districts are carrying out long-term conservation and resource-use programs on the island. These districts all have current memorandums of understanding with the USDA. The department, through its various agencies such as SCS, FS in cooperation with the State Forester, Extension Service, and others, has established a cooperative relationship with each district. Technical assistance is provided to cooperating land owners and operators for the planning and application of conservation measures and the proper management and use of their soil, water, and other related resources.

Conservation work has been proceeding at a generally satisfactory rate and efficient use of the resources is evident in many areas. However, there is considerable opportunity to accelerate the application of land treatment measures, especially on the sugarcane lands which constitute the major cropland use. In areas where there are potentially feasible PL-566 watershed projects, land treatment would be accelerated when these projects are authorized. Acceleration of the conservation program with relation to the provisions of PL-46 should be directed toward:

1. Application of water conservation and erosion control practices.

2. Application of grazing management practices.

3. Establishment of higher yielding forage species.

4. Development of fish, wildlife, and related recreational facilites.

Land treatment measures would protect the soil resource base, permit efficient and effective water management, improve environmental quality, insure the continuation of adequate production to meet present and projected needs, and aid in the development of recreational opportunities. Application of land treatment measures is a primary consideration for full resource development of this island and would require that additional federal funds be made available for acceleration of the existing land treatment programs.

Cooperative State-Federal Forestry Programs

The various cooperative state-federal forestry programs currently in progress in Hawaii facilitate the accomplishment of potential forest resource development. These programs, as previously described in Section VI, are designed to promote sound forest management, protection, and wise use of all state and privately owned forest lands. This section describes the possibilities for development, and the amount of potential development which can be justified under each program. The measures most needed by the year 2000 will be identified, and the interests of landowners and their financial capabilities for meeting the needs will be appraised.

Title IV

To capitalize on the timber production potential and expand the state's resource base, the state government is making modest investments in reforestation with federal cost sharing under Title IV of the Agricultural Act of 1956. In 1961, when the program was initiated in Hawaii, the goal was to develop about 100,000 acres of commercial forest (30 percent of state-owned commercial forest land on the island) by the year 2000. However, only about 18,000 acres in the state (11,300 acres on the island) have been planted during the first 10-year period. The lower than planned level of production is attributed primarily to the fact that available funds have not kept up with rapidly rising costs, and also because of the need to replant some areas due to dry weather conditions, and the difficulty of recruiting labor during critical planting periods. Planned annual production for the next 5-year period has been reduced to 760 acres. Assuming future funding will be made available to maintain the project at the present level, an estimated 33,000 acres or 33 percent of the original goal will be attained by the year 2000.

This program, which has been very effective in developing the island's forest resource, should be continued and hopefully accelerated. Most planting on this island to date has involved extensive site preparation to clear dense stands of vegetation of low commercial timber value. To achieve maximum benefit to watershed values, priority to the year 2000 should be directed to reforestation of commercial forest lands in problem watersheds such as North Kona and Honokaa, where evidence has shown that clearing of forest for intensive pasture use has led to an acceleration of flood runoff. Implementation of such a policy would require termination of state grazing leases, land use zoning changes, and in some cases condemnation or land exchange procedures.

Cooperative Forest Management

Private landowners obtain technical management advice on their individual tracts of land from a State Service Forester under the Cooperative Forest Management Program. Since this program was started in Hawaii in 1964, the workload has increased steadily and this trend is expected to continue as landowners become aware that their lands have substantial values and are economically worth holding and managing for forest products.

About 150,000 of the 380,000 acres of private commercial forest land is in conservation district zoning. Although most of this land is in good hydrologic condition, the majority of it is poorly stocked, unmanaged native forest.

The remaining 230,000 acres of privately owned commercial forest land is in ranch ownership and while it contains remnant stands of native forest cover, present management is directed solely to beef production. In many areas such practice has been at the expense of watershed values. The Conservation Needs Inventory of 1967 estimated that reduction or elimination of grazing is needed on 70,000 acres of such land to improve hydrologic condition. A high priority for the CFM program to the year 2000 will be to provide technical assistance to these landowners in installing measures to improve watershed conditions and to provide a better balance of goods and services from their lands through multiple use management.

Expansion of the CFM program to accelerate the accomplishment of needed forestry land treatment measures will require that certain implementation problems and needs be overcome.

Problems:

1. Land values in Hawaii are speculatively inflated to a level where landowners feel they must obtain larger and quicker returns than can be realized from growing timber. They attribute little or no economic value to other products or services realized from forest land. Thus, land is grazed or left idle.

2. The current lack of stability in the small developing forest products industry, resulting from production and marketing problems, has caused many landowners to be reluctant to make long-term reforestation investments.

3. The high and rapidly increasing costs of reforestation, especially where extensive site preparation is required, discourages reforestation investment. Furthermore, a lack of available manpower on ranches in recent years has led to a reduction in tree planting for windbreaks on open grasslands.

4. Federal cost sharing under the Rural Environmental Conservation Program is not sufficient incentive to plant trees. Since the majority of the privately owned forest land is in large

agricultural corporate ownership, the maximum federal cost share to each owner is too small to encourage large forestry investment. Furthermore, these owners fulfill their entire cost share quota on crop related conservation practices.

Need:

More information is needed on the economics of ranching and timber production as a basis for making land use decisions. Detailed economic studies are needed to evaluate all on-site and downstream benefits and costs of different watershed uses and land management practices.

Forest Products Utilization

Timber utilization can be improved through continued research and technical assistance to loggers, primary wood processors, wood users, and forest landowners. Resource and marketing studies indicate that wood products can be produced from present timber resources to the competitive quality demanded by wood products markets. Expanded utilization and marketing capability will permit greater use of present timber resources and help to promote future resource development.

By the year 2000 a substantial increase in high quality hardwood timber will become available as recently planted stands reach merchantability. In the meantime, a gradual expansion of lumber and plywood production is technically and logistically feasible. Fiberboard or particle board production is also a possibility. Mill residues may not provide a sufficient supply of wood chips, but additional volumes of raw materials could be developed from noncommercial stands and from agricultural by-products, such as the bagasse from sugarcane.

Cooperative Fire Control

To meet the increasing threat from fire, assistance to state and local agencies is being accelerated under the Cooperative Fire Control program. Progress in the development of an effective fire prevention and control program will depend heavily on a coordinated attack by both administrative and research staffs, adopting methods developed elsewhere and developing new knowledge specific to Hawaii. Efforts for effective training program for fire fighting forces, a fire danger rating system, and a fire communication network have become operational. Future research studies will investigate fire behavior in the island's unique fuels, weather, and terrain conditions; and the effectiveness and feasibility of fire retardants and delivery systems, and various types of fuel-break systems.

IX. COORDINATION AND PROGRAMS FOR FURTHER DEVELOPMENT

Basic Considerations

The implementation of an orderly and comprehensive program for development of the island's water and related land resources should be based on coordinated proposals of federal, state, and county agencies that will be accepted by the local people. The current Hawaii Water Resources Regional Study is directed toward this end and will provide the medium for coordinating the programs of the various federal, state, and county agencies involved in land and water resources use and management.

The Hawaii Department of Land and Natural Resources, through its Division of Water and Land Development (DOWALD), also conducts statewide water resources studies. With financial assistance provided under Title III of the Water Resources Planning Act of 1965 (PL 89-80), DOWALD has compiled and published An Inventory of Basic Water Resources Data: Island of Hawaii and is currently preparing a comprehensive water resources development plan for the island that will be incorporated into the Regional Plan.

This study was conducted in cooperation with the Hawaii Department of Land and Natural Resources who requested that "the U.S. Department of Agriculture make a survey of the agricultural, rural, and upstream aspects of the watersheds on the island of Hawaii." To reduce costly duplication and promote complementary actions that would contribute to a fully integrated resource development program, this report has concentrated on the agricultural and forestry aspects of the island's land and water resources and on improvements that could be accomplished under specific USDA programs.

The development proposals for the island can be installed under the programs of the U.S. Department of the Interior. State and county governments can implement other developments required to satisfy future needs. Examples of other developments are: the development of recreational areas by the state of Hawaii and the county of Hawaii; the installation of land treatment and small watershed projects by the local soil and water conservation districts and the county; and water resources development projects by the state of Hawaii.

From an overall resource development standpoint, coordinated efforts on present and future problems are necessary. Future resource development projects must have interagency coordination to insure that the most beneficial use is being made of the resource being considered for development and to harmonize the needs and concerns of the many different interest groups on the island. This coordination may range from informal individual contacts to formal liaison between organizations and agencies.

Successful implementation of resource development programs can occur only with the support of the local people. Their acceptance of these programs will be expedited when they are kept well informed of the programs and actively participate in the decision-making process. Considerable federal, state, and local agency coordination has been accomplished and will be continued.

A coordinated comprehensive program oriented toward a balance of economic, social, and environmental objectives would provide the most desirable development of the land and water resources of the island. This program would have the combined effect of improving the economic and environmental condition of the inhabitants of the island by reducing flood losses and generally enhancing agriculture; providing improved water supplies; and enhancing or preserving the natural values of the environment. A comprehensive program would most nearly achieve all objectives for water and related land resource development for the greatest good of the island's residents. Such a program is contained in the General Plan for the County of Hawaii, the official policy document for the long-range comprehensive development of the island of Hawaii. This document provides the county with the legal basis for all subdivision, zoning, and related ordinances, and for the initiation and authorization of all public improvements and projects.

Other Agency Programs

In addition to the USDA opportunities presented in this report, other federal agencies have proposed developments or are making studies for the island of Hawaii. These programs could have a marked effect on resource development on the island.

The National Park Service, U.S. Department of the Interior, had announced a master plan that would have doubled federal park land on the island of Hawaii. This expansion plan included the addition of 217,000 acres of land and some 5,900 water acres to the national park's existing 211,000 acres. However, due to "negative feedback" from many segments of the Big Island community, this plan has been shelved by National Parks officials, who plan to seek widespread community involvement in preparation for drawing up a new master plan.

The U.S. Army Corps of Engineers is presently studying the state on an island-by-island basis to evaluate problems and needs in the specific areas of navigation, beach erosion, flood control and other related water resource matters. The Corps has already constructed a flood control project in Hilo, conducted a flood plain study for the Kaumana-Punahoa area, and prepared a flood hazard information report for the island of Hawaii.

Several nonfederal agencies are active in developing various aspects of the island's land and water resources. The development activities of various state and county agencies have been described elsewhere in this report. In addition, the State of Hawaii Department of Planning and Economic Development, working closely with these state and county agencies, has analyzed the overall recreational needs of the state and prepared a State Comprehensive Outdoor Recreation Plan.

The laws of the state of Hawaii provide for zoning and land use regulation. The implementation of these zoning statutes will deter or limit the installation of nonagricultural developments in areas subject to flood damages. While various agencies can assist by providing needed information, the implementation of zoning programs is the responsibility of the state and county governments.

Potential Developments Needing Further Coordination With Other Agencies

As indicated elsewhere in this report, the supply of land capable of agricultural production exceeds the amount that can be irrigated with present water supplies. Approximately 70,000 acres could be brought into production should additional irrigation water become available. Coordinated appraisals by all concerned interests would be essential in determining the need and practicability of such proposals.

A need for land and water areas for recreational uses was recognized in the process of projecting future resource use. However, since a State Comprehensive Outdoor Recreation Plan has been prepared, no attempt was made to do more than recognize this need and indicate likely areas that have potential for future recreational development (Figure 7.2).

The land-managing and conservation agencies must continue to work closely with state and county agencies to determine the best use and management of the island's land and water resources. The relationship of soils to suburban and recreational development is an example of a significant item that should be considered in the planning process. Agricultural taxation and land use zoning may be other areas where detailed resource analysis could assist in determining logical courses of action.

New Programs or Modifications of Existing Programs

Since changes in technology will continue to occur, existing programs have been and must continue to be modified to meet changing needs. The emphasis on conservation in the past has largely focused on erosion control in order to maintain fertility and productive capacity of the land. Presently and in the future, emphasis on conservation will include environmental concerns, such as air and water quality, channel cutting and filling, and overall landscape beautification. These changing public demands and values will necessitate programs to provide more incentive to land owners and operators to participate in all phases of soil and water conservation treatment, improve wildlife habitat and recreation opportunities, and provide for environmental enhancement.

Measures contributing to these objectives would include:

For croplands - minimum tillage, terraces, diversions, conservation cropping systems, crop residue use, and vegetated waterways.

For pasturelands - proper management of pastures, water development, and weed and brush control measures.

For forest lands - resource development on idle forest land and forest lands presently managed for single-use, to achieve a pattern of uses that will meet a variety of needs of the people now and in the future. Measures would include reduction or elimination of grazing on forest lands critical for water yield or tributary to flood problem areas; and reforestation for watershed, timber production, recreation, and wildlife habitat improvement.

Changes in present programs or addition of new programs are also needed to fully develop the water and related land resources and enhance the environment. An islandwide land treatment program would assist farm and ranch operators plan and contract for the installation of complete conservation programs according to agreed schedules.

Existing provisions of the Watershed Protection and Flood Prevention Act (PL-566) were not always found to be compatible to the defined needs of some of the island's watersheds. Project formulation in many areas would depend on agriculture water management and/or rural water supply, with flood control considerations being secondary. These purposes seem to offer the best and most needed benefits to most of the island and a recognition of this fact would be helpful in increasing the applicability of PL-566.

APPENDIX A

National and Regional Economic Framework 1/

Baseline projections being used in the national and regional framework studies by federal and state agencies under the program of the Water Resources Council have been developed in preliminary form by the U.S. Department of Agriculture Economic Research Service and Office of Business Economics for the Water Resources Council. They also constitute a base framework of projections for regional plans and USDA Type IV studies. The projections are shown in preliminary reports released by these agencies in March 1971 and August 1967.

Projections of population, employment, and income were made for each Water Resource Region, including Hawaii. All states and regions were included in estimating demands for food and fiber; however, regional allocations of this total demand were not made to Alaska and Hawaii. Production in these states and regions has been placed in a residual "import" quantity over and above projected production in the continental United States.

Demand and production of sugarcane, pineapples, and beef cattle, which are major sources of agricultural income in Hawaii, are emphasized. In 1970, total crop and livestock sales were estimated at nearly $213,000,000, of which about $171 million was crop sales and $42 million was sale of livestock and livestock products.2/ The value of unprocessed sugarcane comprised 65 percent and the value of pineapple sales, 23 percent of all crop sales. Cattle sales were 33 percent of all livestock and product sales.

Population and Employment

The projections of agricultural demand (food and fiber) at the national level were based on a Series C set of population projections prepared by the U.S. Bureau of Census. For information purposes, these population figures for the 50 states are:

Year	Population (millions)	Change (percent)
1960	180.7	100
1980	235.2	130
2000	307.8	170
2020	398.6	220

The U.S. population was about 180 million in 1960. It had increased to about 203,200,000 by July 1969.

1/ Prepared by Stewart, Clyde E. and Karl Gertel, Economic Research Service, USDA, April 1972.

2/ Statistics of Hawaiian Agriculture, USDA, Statistical Reporting Service, July 1968.

The Office of Business Economics projects that the population of Hawaii will increase nearly three times, to 1,424,369 by 2020 (Table A). Total employment will increase about in the same proportion or to about 614,000 persons. Employment in agriculture, forestry, and fisheries is projected to decrease greatly over the next 50 years, from about 16,000 in 1960 to less than 7,000 by 2020 (Table A).

National Demand and Production Requirements

Total projected demand is a combination of numbers of people and estimated consumption per capita. Demand projections for 2000 and 2020 utilize the 1980 projections of consumption per capita. Selected national per capita consumption are as follows:3/

	1959-61 (pounds)	1980 (pounds)
Beef (carcass wt.)	84.7	112.0
Eggs (number)	337.0	290.0
Milk (fat solids basis)	657.0	570.0
Sugar (raw equiv.)	104.0	104.0
Vegetables (fresh basis)	205.0	216.0
Melons (fresh basis)	25.0	20.0
Citrus fruits (fresh basis)	82.0	84.0
Noncitrus fruits (fresh basis)	113.0	122.0
Tree nuts (shelled)	1.6	1.6

3/ Similar quantities are shown for all agricultural commodities in the projections report of 1967 by Economic Research Service.

Table A. Population and Employment, State of Hawaii, 1940 to 2020

Year	Population	Employment		
		Total	Agriculture, Forestry, Fisheries	Food and Kindred Products
1940	426,000	180,796	55,064	10,593
1950	499,000	190,444	31,982	12,623
1959	610,000	256,637	16,308	19,978
1970	775,600	320,300	13,500	21,900
1980	863,524	369,000	9,600	20,000
2000	1,114,556	480,000	7,100	21,000
2020	1,424,369	614,000	6,700	22,000

Source: Water Resources Council Projections Report, Hawaii Water Resource Region, 1971.

The projected demand including exports for selected agricultural commodities based on population in the 50 states is as follows:

Commodity	Unit	1959-61	1980	2000	2020
			-000-		
Sugar (raw)	Tons	9,500	12,371	16,198	20,910
	Percent	100	130	170	220
Fruits & Vegetables					
Citrus	Tons	8,300	11,124	14,105	17,935
Noncitrus	Tons	11,000	15,535	20,020	25,500
Vegetables & Melons	Cwt.	447,000	628,145	813,540	1,045,500
Tree nuts (shelled)	Lbs.	315,000	459,361	571,480	712,300
Beef & Veal					
Carcass	Lbs.	16,509,000	27,667,000	36,144,000	46,780,000
Live	Lbs.	29,864,000	48,694,000	63,614,000	82,333,000

Projected production of selected commodities in the United States is shown below.4/

Commodity	Unit	1959-61	1980	2000	2020
			-000-		
Sugar (raw)	Tons	3,290	7,300	11,400	16,500
Fruits & Vegetables					
Citrus	Tons	8,028	11,000	14,100	17,900
Noncitrus	Tons	9,952	12,600	17,200	22,900
Vegetables & Melons	Cwt.	403,902	615,900	801,800	1,034,600
Tree nuts (shelled)	Lbs.	170,000	147,700	275,700	436,000
Beef & Veal					
Carcass*	Lbs.	15,894,000	25,028,000	33,323,000	43,728,000
Live	Lbs.	28,898,500	45,506,000	60,588,000	79,506,000

Series C population
*Estimated as 55 percent of live weight.

The difference between projected demand (50 states) and continental U.S. production (48 states) results in an estimate of necessary imports, including production in Hawaii and Alaska. These estimates for selected products are shown below. Apparently, projected production in the 48 states increases relatively more than projected demand for the crops below since projected "imports" decline during the 50-year period. A similar decline is shown for live weight of beef and veal also.

4/ Excludes Hawaii and Alaska. From Economic Research Service projections report.

Commodity	Unit	Imports (48 states) 1959-61	1980	2000	2020
			-000-		
Sugar (raw)	Tons	6,210	5,071	4,798	4,410
Fruits & Vegetables					
Citrus	Tons	272	124	5	35
Noncitrus	Tons	1,048	2,935	2,820	2,600
Vegetables & Melons	Cwt.	43,098	12,245	11,740	10,900
Tree nuts (shelled)	Lbs.	145,000	311,661	295,780	276,300
Beef & Veal					
Live	Lbs.	965,500	3,188,000	3,026,000	2,827,000

Sugar Quotas and Prices

Sugar quotas based on estimated sugar consumption in the United States for 1969 and 1970 were as follows:

	Raw Value - Short Tons 1969	1970[5/]
Domestic beet area	3,215,667	3,263,333
Mainland cane	1,169,333	1,186,667
Hawaii cane	1,190,673	1,150,000 [6/]
Puerto Rico cane	1,140,000	1,140,000 [6/]
Virgin Islands cane	15,000	15,000
Total Domestic	6,730,673	6,755,000
Total Foreign	2,601,543	4,145,000
TOTAL	9,332,216	10,900,000

5/ USDA Agricultural Stabilization and Conservation Service, Sugar Reports, No. 210, Washington, D.C., Nov. 1969.

6/ Direct cons. limits - Hawaii 32,278 tons and Puerto Rico 163,500 tons.

By way of comparison, production of sugar (raw value) in 1968 was as follows:

	Short Tons*
Domestic beets	3,500,000
Mainland cane	1,209,000
Hawaii cane	1,232,000
Puerto Rico cane	645,000
Virgin Islands cane	0
Total Domestic	6,586,000

*USDA Agricultural Statistics, 1968

Prices per ton of cane are somewhat higher in Hawaii than on the continent (Table B). However, sugar content is also higher. For example, sugar per ton of cane in 1968 averaged 202 lbs. for the U.S., 205 lbs. for Florida, 183 lbs. for Louisiana, and 214 lbs. for Hawaii.7/

Current normalized prices of sugarcane on the continent are $7.80 per ton. This price was developed for projection purposes on the basis of historical levels and trends. A current normalized value for Hawaii, or including Hawaii, would be larger. This $7.80 value does not include government payments.

The farm price of beef has averaged about $21.00 per cwt. liveweight during the past 10 years. Big Island prices averaged 40¢ to 50¢ less per hundred than state average prices.8/

Regional Agricultural Production

The state of Hawaii produces about 11 million tons of sugarcane per year. Total production has increased during the past 10 years as a combination of increases in acreage harvested and tons yield per acre.9/ 1959-61 average production of sugar (raw value) was about 1,001,000 tons; a similar production in 1968 was 1,232,000 tons.10/ Nearly 45 percent of total sugar production is on the Big Island.

7/ USDA Agricultural Statistics 1968, p. 83.

8/ USDA State Statistics publication.

9/ Statistics of Hawaiian Agriculture, op cit.

10/ USDA Agricultural Statistics, op cit.

Table B. Prices of sugarcane, United States (Mainland) and Hawaii

Year	U.S. Prices *	Hawaii State **	Hawaii Government Payments ***
	$/ton	$/ton	$/ton
1955-64	7.71		
1960-64	8.20		
1960	7.41	7.80	1.02
1961	7.67	8.20	1.04
1962	8.35	8.80	1.04
1963	10.20	10.90	1.00
1964	7.39	8.60	1.01
1965	7.90 ****	9.00	0.99
Current Normalized	7.80		
Adjusted Normalized	7.80		
1966	8.49 ****	9.60	0.98
1967	9.38 ****	9.60	0.96
1968	9.35 ****	10.00	0.97

State/U.S. price ratio - current normalized
Sugarcane: Florida - 1.09
La. - 96

* Excludes payments under Sugar Act. From "Interim Price Standards." Prices do not include Hawaii.

** Excludes government payment. Data from "Statistics of Hawaiian Agriculture, 1968," p. 18.

*** Calculated on basis of total tons production and total government payments. From "Statistics of Hawaiian Agriculture, 1968," p. 18.

**** USDA Agricultural Statistics 1968, p. 82.

In 1964, production of sugarcane for the state by counties was:

	State	Hawaii	Honolulu	Kalawao*	Kauai	Maui**
Land in crop Acres	233,387	104,440	35,769	-	49,821	43,357
Harvested						
Acres	110,803	47,159	17,798	-	24,289	21,557
Tons (Cane)	10,740,597	4,690,137	1,753,893	-	2,113,047	2,183,520

*Small portion of Molokai.

**Maui, Lanai and most of Molokai.
U.S. Census, 1964.

Liveweight production of cattle and calves sold is about 60 million pounds. Quantity produced and sold has increased substantially since 1959-61 when sales liveweight were around 45 million pounds. About 65 percent of total beef production in Hawaii is on the Big Island.

Volume of sales of other major crops in 1968 were:11/

	1,000 lbs.
Vegetables and melons	49,655
Fruits (excluding pineapples)	39,107
Coffee (parchment)	6,180
Macadamia nuts (in shell)	10,151
Taro	9,140

All coffee and macadamia nuts are produced on the Big Island, as well as about 35 percent of the vegetables and melons, and 65 percent of fruits other than pineapple. For major Hawaiian products other than pineapple, the "import" or "demand loss 48 states production" is much greater than Hawaiian output. Obviously, the future of Hawaiian agriculture hinges also on factors other than projected U.S. demands.

Sugarcane yields in Hawaii average about 100 tons per harvested acre. However, in Hawaii, nearly two years are required for a crop so that acreage in sugarcane is about double harvested acres.

Sugar production, raw value equivalent in terms of 96° sugar, averaged 214 pounds per ton of cane in 1968, or nearly 11 percent. Refined sugar basis conversion in 1968 was 93.46 pounds per 100 pounds of raw sugar.

Production Requirements - Hawaii

In view of the possibility of incorporating Hawaii agricultural production into a national and interregional model of production needs, Economic Research Service prepared some preliminary projections for the Hawaii Region for selected commodities (Table C). Major increases shown are for sugar, beef, cattle, and milk.

Table C. Preliminary Regional Production Requirements - Hawaii

Commodities	Units	1959-61	1970	1980	2000	2020
Farm Chickens	mil. lbs.	2.0	1.3	3.0	3.0	3.0
Eggs	no. mil.	132.0	197.0	200.0	200.0	200.0
Milk	mil. lbs.	124.0	137.0	200.0	200.0	200.0
Broilers	mil. lbs.	5.0	6.5	6.0	6.0	6.0
Sugarcane, raw (equivalent)	mil. lbs.*	2002.0	2324.0	3000.0	3000.0	3000.0
Irish Potatoes	mil. lbs.	0.4	0.5	0.4	0.4	0.4
Sweet Potatoes	mil. lbs.	1.3	0.8	0.8	0.8	0.8
Fruits, excluding pineapple	mil. lbs.	--	36.0	42.0	NA	NA
Pineapple (fresh)	mil. lbs.	--	1832.0	1800.0	NA	NA
Vegetables & Melons	mil. lbs.	48.6		55.0	55.0	55.0
Nuts (macadamia)						
In shell	mil. lbs.	2.9	11.5	NA	NA	NA
Shelled**	mil. lbs.	1.0	4.0	NA	NA	NA
Beef & Veal	lwt. mil. lbs.	47.0		65.0	65.0	65.0
Pork	lwt. mil. lbs.	12.0		12.0	12.0	12.0

*Convert to tons by multiplying by 5.5555.

**Shelled (65 percent loss in shelling).

Preliminary and unpublished projections by ERS, 9-16-69.

Later, projections for sugar production were revised downward (Table D). These projections provide for some increase in acreage and rather substantial increases in yields and total production over the next 50 years.

Table D. Preliminary Sugar Projections, Hawaii, Base Periods and Projection Years

Item	1959-61	1963-65	1980	2000	2020
Acres harvested	107,300	109,300	111,000	111,000	111,000
Production - Cane					
Total	9,185,000	10,427,000	11,711,000	12,321,000	12,709,000
Per acre	85.6	95.4	105.5	111.0	114.5
Pounds raw sugar/ ton cans	218	224	217	213	210
Sugar - raw tons	1,001,000	1,166,000	1,271,000	1,312,000	1,334,000

Preliminary and unpublished projections by ERS. January 1970.

APPENDIX B

Agricultural Projections Methodology[1/]

The general procedure for projections was, first, to review existing studies on statewide consumption and production of agricultural products. Where appropriate, existing projections were adopted and extended to 1980 as needed. In other cases, independent projections were made. For each product, production in Hawaii County was derived by judgment based on study of recent trends and aided by statewide studies of the distribution of production among counties where available. Acreages in Hawaii County were obtained by evaluating trends of yield and several research studies.

Whenever available, the demand and supply functions developed by Renaud[2/] were extended to 1980 since they had higher correlation coefficients than those developed by Collier (Table A). For Chinese cabbage, celery, and daikon, the demand and supply functions developed by Collier were employed. Because of the rapid decline projected in consumption rates for locally grown bananas, the 1975 consumption per capita was assumed to remain unchanged through 1980. To test the consistency of the analysis by Renaud and Collier, projections of identical crops were developed to 1980 using functions of both Renaud and Collier. Except for lettuce, results were quite similar. Similar notes for other products are made later under specific crop and livestock items.

1/ Prepared by Stewart, Clyde E., and Karl Gertel, Economic Research Service, USDA, April 1972.

2/ Renaud, Bertrand M., The impact of economic growth on the trade structure of an island economy - the case of agriculture in Hawaii. Hawaii Agricultural Experiment Station Technical Bulletin 84. In process.

Table A. Sources and Coefficients of Determination for Statewide Agricultural Demand and Supply, 1980

Produce	Source	Coefficient of Determination R^2	
		Demand	Supply
Chinese cabbage	Collier	.51*	.58*
Celery	Collier	.21**	.73*
Cucumbers	Renaud (extended to 1980 for this study)	.79*	.73*
Daikon	Collier	.59*	.24*
Head Cabbage	Renaud (extended to 1980 for this study)	.77*	.78*
Lettuce	Renaud (extended to 1980 for this study)	.89*	.94*
Tomatoes	Renaud (extended to 1980 for this study)	.56**	.77*
Avocados	Renaud (extended to 1980 for this study)	.70*	.68*
Bananas	Renaud (1975 demand projections accepted for 1980). Supply projected as equal to demand	.65*	--
Papayas	Renaud (no significant trends; 1967 level adopted for demand). Renaud (extended supply to 1980 for this study)	--	.90*
Macadamia nuts	Renaud (1975 projections of demand accepted for 1980)	.92*	--
	Linear extrapolation of acreage in crop yields as estimated by Scott	--	(for acreage) .87*
Raw Sugar	Renaud from national projections. Acreage and yield as estimated by ERS for national model	--	--
Beef and veal	Renaud (extended to 1980 for this study	.90*	--
	State of Hawaii Agricultural Plan - supply	--	--

*Significant at 99 percent level of probability.
**Significant at 95 percent level of probability.

The county's share of statewide production was estimated by judgment for each commodity using historic shares, results from Collier who estimated optimal distribution of production in 1980 by counties and regression extrapolations. Results are summarized in Table B.

Table B. Alternative Estimated of Hawaii County's Share of State Production for Selected Major Agricultural Products

Product	Average 1960-1968	Collier thesis	Regression Extrapolation	Share Adopted
	- - - - - - - - - - - - - percent - - - - - - - - - - - - -			
Chinese Cabbage	66	47-99	100	85
Cucumbers	39	23-43	61	50
Daikon	67	100	n.s.	80
Head Cabbage	11	11-21	n.s.	11
Lettuce	51	0-60	86	65
Tomatoes	45	0-38	75	50
Avocados	81	n.a.	97	85
Bananas	28	n.a.	56	35
Papayas	73	n.a.	100	85
Macadamia Nuts	98	n.a.	not tested	80
Beef and Veal	55	n.a.	not tested	66
Raw Sugar	36	n.a.	n.s.	36

n.s. - No significant trend evident
n.a. - Not available

Acreage for individual crops in 1980 was estimated by dividing the projected 1980 production by projected yields. Yields for 1980 were estimated by using historic yields, estimates by Collier, projections for 1973 given in Projections for Big Island Agriculture and regression extrapolation. Results are summarized in Table C.

Table C. Alternative Estimates of Yields Per Acre for Major Crops, Hawaii County

Crops	Average 1960-1968	Collier thesis	1973 projections	Regression extrapolation*	Yield adopted for 1980
	---------- 1,000 pounds ----------				
Chinese cabbage	14.6	17.8	18.0	n.s.	18.0
Celery	39.3	30.4-42.0	38.1	14.2	below profitable level
Cucumbers	25.2	45.0	37.0	49.7	45.0
Daikon	10.5	11.0	9.5	n.s.	9.5
Head cabbage	13.9	14.9	15.0	n.s.	15.0
Lettuce	12.6	12.7	13.5	n.s.	13.5
Tomatoes	26.7	35.4	50.0	52.6	50.0
Avocados**	6.0	n.a.	n.a.	8.8	8.8
Bananas	11.0	n.a.	n.a.	n.s.	11.0
Papayas	28.7	n.a.	32.9	39.3	35.0
Macadamia nuts***	2.5	n.a.	n.a.	3.8	4.2
	Tons		Tons	Tons	Tons
Raw sugar	8.8	n.a.	10.5	11.4	10.5

*Regression extrapolations to 1975.
**Applies to varieties harvested in 1967.
***Reflects harvesting from orchards of varying maturity.
n.s. = no significant trend evident.
n.a. = not available.

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